First edition	1952
Second edition	1958

LUMBAR DISC LESIONS

PATHOGENESIS AND TREATMENT OF LOW BACK PAIN AND SCIATICA

BY

J R ARMSTRONG

M D., M Ch., F R C.S

Orthopaedic Surgeon to the Metropolitan Hospital, Orthopaedic Surgeon to Lambeth Hospital Visiting Orthopaedic Surgeon to Manor House Hospital (Industrial Orthopaedic Society), Honorary Consulting Orthopaedic Surgeon to Royal Waterloo Hospital for Children and Women, Late Visiting Orthopaedic Surgeon to the Ministry of Pensions Hospital Stoke Mandeville, Late Orthopaedic Specialist, Royal Air Force Medical Service

FOREWORD BY

H OSMOND-CLARKE

C.B.E., F R.C.S

Orthopaedic Surgeon London Hospital, Senior Visiting Surgeon, Robert Jones & Agnes Hunt Orthopaedic Hospital Oswestry Civilian Consultant in Orthopaedic Surgery to the Royal Air Force

SECOND EDITION



E & S LIVINGSTONE LTD
EDINBURGH AND LONDON
1958

Printed in Great Britain at THE CENTRAL PRESS, ABERDEEN

FOREWORD

THERE is hardly any group of ailments which requires such careful evaluation when planning treatment as lesions of the lower lumbar intervertebral discs Much has been written about them—some of it good some bad—in the last twenty years and there will no doubt be more in the future The present monograph is the product of accurate and inquisitive clinical observation a comprehensive survey of the literature and an experience of more than a thousand well documented opera tions Mr Armstrong is deliberately provocative didactic and repetitive there is much in the story of the prolapsed intervertebral disc which deserves and indeed requires repetition! His work portrays for the most part the views of contemporary British orthopaedic surgeons For example it is very rightly pointed out that a degenerative disc lesion produces a mechanical disturbance of the spine which may have far reaching consequences. Involvement of a root of the sciatic nerve is often the most dramatic presentation in the clinical picture but the cure of the sciatica either by conservative or operative means is not always the end of the story—as some surgeons appear to think. Mr Armstrong does well to emphasise that a damaged disc means at best a painless fibrous ankylosis between two vertebral bodies at worst a painful unstable joint requiring a fusion operation

Mr Armstrong s sane approach which expresses clearly the correct place of both conservative and operative treatment will form an admirable guide to all who have to deal with this often recalcitrant problem

H OSMOND-CLARKE

LONDON

PREFACE TO SECOND EDITION

IT would be pleasant to record that since this book was first written six years ago our approach to the problems of low back disorders had become more confident. This does not appear to me to be true however While I do not believe that there are any very large gaps in our present knowledge of these conditions we do not seem to be able to classify or think of them in an orderly or logical way Even the nomenclature used is applied to different conditions in a haphazard way and without any relation to pathology

Lumbar disc lesions can no longer be considered a new disorder but they remain a major cause of low back pain with or without sciatica It seems to me that during the past few years enough has been added to our knowledge of these lesions to justify a second edition of this book

The treatment of disc lesions has not in my view advanced a great deal. Far too often therapy is conducted on a purely emotional level patient and doctor alike demand some dramatic measure preferably with a mechanical basis. Something has slipped out of place it must be put back It is true that manipulation seems to be less popular than it was but its place has largely been taken by traction another of the more irrational manifestations of therapeutic exuberance

My thanks are due to those friends and in particular to Mr Cecil Fleming who have encouraged me in my interest in low back disorders. Mr Charles Macmillan of Messrs. E. & S Livingstone has been as always a tower of strength Miss Thackstone, my secretary has dealt with relays of manuscripts and proofs with unfailing cheerfulness and skill

J R ARMSTRONG

LONDON 1958

PREFACE TO FIRST EDITION

LOW back disorders are so common that it is interesting to speculate why this region should be a weak spot in the human locomotor system When long ago in late Oligocene times man forsook the trees to walk upright on the ground he made novel demands on his lumbo-sacral spine It may be that the process of adaptation is still incomplete.

Only in the past twenty years has any satisfactory classification of these dis orders become possible Before this the gaps in our knowledge were too great to permit a clear picture to be formed With the recognition of disc lesions many previously inexplicable clinical phenomena were understood and interest in these lesions stimulated much research and a new approach to the problems of the low back.

The importance of disc lesions has been a matter of much controversy Changes in fashion are not an exclusively feminine prerogative and a newly discovered condition may very quickly become a medical mode This phase seems to have passed few would now claim that disc lesions are either excessively rare or that they are the only cause of low back pain with or without sciatica There is at present a widespread impression that disc disorders are becoming more common Such a belief has no real foundation The public are attracted by a new term patients who ten years ago took their lumbago or fibrositis for granted and in silence now gossip with some pride of their slipped disc

For years I have been interested in low back disorders. Quite early in the war it became obvious that their incidence among the personnel of the Royal Air Force was surprisingly high and warranted special measures to ensure effective treatment Since 1945 I have seen many more patients with such disorders not only in ordinary hospital and private practice but in the hospitals of the Royal Air Force the Ministry of Pensions and the Industrial Orthopaedic Society In some hospitals clinics dealing only with low back lesions have been established and these clinics grow very quickly The surgeon specialising in the low back has many patients referred to him by his colleagues for operation when conservative measures have failed Although not all these do require surgery the percentage operated on is much higher than in previously untreated patients Thus special experience is gained of the macroscopic pathology of disc lesions and of the problems associated with their surgical management. This monograph is based on experience acquired in this way

I wish to record my gratitude to those who have been of so much assistance to me My colleagues and in particular Mr H Osmond-Clarke Mr Cecil Flem ming and Sir Reginald Watson Jones, have helped and encouraged me in this work. Mr Osmond-Clarke has written a Foreword to this monograph which reflects his mature and balanced approach to these problems. Mr B H Burns and Mr

Robert Young have made me free of their unique experience of disc lesions Mr Charles Macmillan of Messrs. E. & S Livingstone has been as always unfailingly helpful and Miss Whiteside who has illustrated the monograph, has done her best to beautify my line drawings and has watched patiently many operations in order to produce her fine coloured plates Finally my special thanks to Miss Caw for the willing and expert secretarial aid in her laborious task of completing the manuscript.

J R. ARMSTRONG

LONDON 1952.

CONTENTS

CHAPTER I

INTRODUCTION

Thou cold sciatica
Cripple our senators that their limbs may halt as
lamely as their manners [1]

THE relationship between lesions of the lower lumbar intervertebral discs disorders of the low back and pain felt in the posterior aspect of the leg is now well established. The diagnosis of a prolapsed or retropulsed' inter vertebral disc is so commonplace that it is difficult to remember that the condition thus described has only been recognised during the past 21 years. On the other hand part of the syndrome now associated with a disc lesion has been a household word—sciatica—for centuries

It seems reasonably certain although perhaps not yet universally accepted that disc lesions are at least the commonest cause of both low back and sciatic pain Until this was recognised the aetiology of lumbago and sciatica was a matter of speculation and their treatment was largely empirical.

The discovery of the connection between the lower lumbar discs and the lumbago-sciatica syndrome was not the result of any single investigation Although the value of the contribution made by Mixter and Barr[2] cannot be overestimated all the necessary facts were known for years before they published their epoch making paper in 1934

When the work bearing on this particular problem is considered in chronological order it is strikingly obvious that medical opinion was advancing step by step towards the present conception of a lesion of one of the lower lumbar discs involving one root of the sciatic nerve in its extrathecal course and producing symptoms referred both to the low back and to the distribution of the affected root.

The discs themselves were first described by Vesalius[3] in 1555 More than two centuries later in 1764 an Italian Dominico Cotunio (or Cotugnio),[4] described sciatica as a clinical entity in his " De Ischiade Nervosa Commentarius." Following the publication of this treatise sciatica was known as Cotunio s Disease for many years.

The close association between sciatica and low back pain does not seem to have been clearly recognised until 1864 when Lasègue[5] described the carriage and posture characteristically associated with sciatica. A little later Charcot[6] also described the typical spinal deformity and Brissot[7] coined the term sciatic scoliosis.

[1] Shakespeare William (1608) *Timon of Athens* iv 1
[2] Mixter W J., & Barr J S (1934) Rupture of the intervertebral disc with involvement of the spinal canal *New Engl J Med.*, 211 210-215
[3] Vesalius, A. (1555) *De Humani Coporis Fabrica* Libri septem, Basileae per J Oporinum.
[4] Cotunio (Contugnio), Dominico (1764) *De Ischiade Nervosa Commentarius*
[5] Lasègue, C (1864) Considerations sur la sciatique *Arch gén Méd* 2, 558
[6] Charcot (1888) *Leçons du Mardi*
[7] Brissot (1890) Des scolioses dans les neuralgies sciatiques. *Arch. Neurol Paris.*

Some years earlier in 1857 Virchow[8] had been responsible for a much fuller account of the intervertebral discs and a report of the tumour associated with his name. An even more complete description of the discs was published by Von Luschka[9] in 1858. In 1895 Ribbert[10] reproduced Virchow's tumour by puncturing the intervertebral discs in rabbits.

In 1896 Kocher[11] described the finding at post mortem of a gross posterior displacement of the disc between the first and second lumbar vertebrae in a man who had fallen 100 feet to land in a standing position. This appears to be the earliest report of an actual posterior displacement of intervertebral disc material.

In 1911 Goldthwait[12] published a paper which is noteworthy in that it contained a diagram showing an absolutely typical nuclear retropulsion of the disc between the fifth lumbar and first sacral vertebrae. Goldthwait's attention had been directed to this condition when a patient suddenly developed a cauda equina compression lesion while undergoing treatment for sacro-iliac strain. As a result of his investigations he concluded that subluxation of the lumbo-sacral joint was a common cause of lumbago and sciatica. He believed that such subluxations were usually associated with, and probably due to congenital abnormalities in this region and postulated that subluxation might be accompanied by posterior displacement of the L5 S1 disc in many cases.

Also in 1911 Middleton and Teacher[13] in Glasgow described paraplegia of sudden onset occurring in a man of 38 who felt something "snap" in his back while he was lifting a heavy weight and in whom retropulsion of the disc between the twelfth thoracic and first lumbar vertebrae was found at autopsy 16 days later.

In 1916 two different suggestions were made each of which profoundly influenced medical thought for many years.

Elsberg[14] described certain extradural tumours of the spinal canal which he called chondromata. During the next 16 years many reports of such "chondromata" were published[15] and it seems clear that some surgeons recognised that these did in fact consist of displaced disc material.

[8] Virchow R. (1857) *Untersuchungen über die Entwickelung des Schädelgrundes im Gesunden und Krankhaften Zustande und über den Einfluss derselben auf Schädelform Gesichtsbildung und Gehirnbau* Berlin, G Reimer
Von Luschka, H (1858) *Die Halbegelenke des menschlichen Korpers* Berlin, G Reimer

[10] Ribbert (1895) Ueber die experimentalle Erzugung einer Ecchondrosis physalifora. *Verh. congr innere Med., Wiesb* 13, 455-464

[11] Kocher T (1896) Die Verletzungen der Wirbelseule zugleich als Beitrag zur Physiologie des Menschlichen Ruckenmarks. *Mitt Grenzgeb Med Chir.*, 1 420.

[12] Goldthwait, J E. (1911) The lumbo-sacral articulation an explanation of many cases of lumbago sciatica and paraplegia *Boston med surg J.*, 164, 365

[13] Middleton, G S., & Teacher J H (1911). Injury of the spinal cord due to rupture of an intervertebral disc during muscular effort. *Glasg med J.*, 76, 1

[14] Elsberg, C A (1916) *Diagnosis and Treatment of Surgical Disease of the Spinal Cord and its Membranes* Philadelphia and London, W B Saunders & Co

[15] Reports of "Extradural chondromata" were made by the following Steinke 1918 Clymer Mixter and Mella, 1921 Adson 1922 Ott, 1925 Desjaques 1927 Holm, 1928 Elsberg, 1928 Stookey 1928 Alajouanine and Petit Dutaillis, 1928 and 1930 Von Pechy 1929 Veraguth, 1929 Kortzeborn, 1930 Klinge, 1930 Krabbe 1930 Bucy 1930 Couron Petit Dutaillis and Christophe 1931 Ellmer 1932 Werthemann and Rintelen, 1932 Alpers, Grant and Yakin, 1933 Petit Dutaillis, 1934

In the same year Sicard[16] published a paper in which he postulated that sciatica was commonly due to an irritative lesion of the roots of the sciatic nerve in their intraspinal course. He suggested that the term 'neurodochitis' might be used to describe this condition. This theory as to the cause of what was then called 'essential' or 'ideopathic' sciatica found wide acceptance during the next ten years. In 1927 Putti[17] in his Lady Jones Lecture summarised the views of those who belonged to this school of thought. Putti suggested that irritations or inflammations of the sciatic nerve might be classified according to the site of the causal lesion. He suggested the terms radiculitis, ganglionitis, funiculitis, plexitis and neuritis, and in his view most sciatica was due to irritation of the nerve roots in the spinal foramina. He further believed that this irritation was secondary to an arthritis of the posterior intervertebral articulations and that this arthritis was closely associated with variations in the plane of the articular facets of the posterior intervertebral joints. Thus in Putti's view sciatic pain could be satisfactorily correlated with the associated low back disorder.

About the same time Schmorl of Dresden was carrying out intensive investigations of the anatomy and pathology of the intervertebral discs. Between 1927 and 1931 he published 11 papers containing a mass of previously unrecorded information.[18] In 1931 Beadle,[19] working at Dresden under the auspices of the Medical Research Council, published further observations on the normal and morbid anatomy of the intervertebral discs. It may seem strange that in spite of the wealth of material examined neither of these workers observed lesions of the lower lumbar discs with associated nuclear retropulsion, but it should be remembered that most of their findings were based on radiological examination or on post mortem dissection of spinal columns.

One other noteworthy paper was published during this time. In 1929 Dandy[20] reported that in two cases he had found cartilaginous fragments lying loose in the

[16] Sicard, J. A. (1916). Les sciatiques. sciatiques par blessures de guerre: sciatiques medicale. *Marseille méd.*, 53, 2.
[17] Putti, V. (1927). New conceptions in the pathogenesis of sciatic pain. *Lancet*, ccxiii, 53.
[18] Schmorl, G. (1927). Über die an den Wirbelbandscheiben vorkommenden Ausdehnungs und Zerreissungsvorgänge und die dadurch an ihnen und der Wirbelspongiosa hervorgerufenen Veränderungen. *Verh. dtsch. path. Ges.*, 22, Tagung, 250.
(1928) (a). Über bisher nur wenig beachtete Eigentümlichkeit ausgewachsener und kindlicher Wirbel. *Arch. klin. Chir.*, 150, 420.
(1928) (b). Über Knorpelknötchen an den Wirbelbandscheiben. *Fortschr. Röngenstr.*, 38, 265.
(1928) (c). Zur Kennetnis der Wirbelkörperepiphyse und der an ihr vorkommenden Verletzungen. *Arch. klin. Chir.*, 153, 35.
(1928) (d). Über Chordareste in den Wirbelkorpern. *Zbl. Chir.*, 55, 37, 2305.
(1929) (a). Zur pathologischen Anatomie der Wirbelseule. *Klin. Wschr.*, 8, 1243.
(1929) (b). Verkalkung der Bandscheiben der Wirbelseule nebst Bemerkungen über das Verhalten der Bandscheiben bei infektloser Spondylitis. *Fortschr. Röntgenstr.*, 40, 18.
(1929) (c). Über Knorpelknotchen an der Hinterfläche der Wirbelbandscheiben. *Fortschr. Röntgenstr.*, 40, 629.
(1929-30). Die Pathogense der juvenilen Kyphose. *Fortschr. Röntgenstr.*, 41, 359.
(1930). Zur Sektionstechnik der Wirbelseule. *Zbl. allg. Path. path. Anat.*, 48.
(1931). Über die pathologische Anatomie der Wirbelbandscheiben. *Bruns' Beitr.*, 151, 360.
[19] Beadle, O. A. (1931). *The Intervertebral Discs*. London, The Medical Research Council (H.M.S.O.).
[20] Dandy, W. E. (1929). Loose cartilage from intervertebral disc simulating tumour of the spinal cord. *Arch. Surg.*, 19, 660-672.

spinal canal. There can be little doubt that these fragments were, in fact, extruded pieces of sequestrated nuclear tissue.

On 30th September 1933 Mixter and Barr[21] presented their historic communication to the Annual Meeting of the New England Surgical Society in Boston. In this paper they pointed out that Schmorl's post-mortem investigation of lesions of the intervertebral discs had stimulated much interest in this problem They also pointed out that many cases of compression of the cauda equina or nerve roots by so-called chondromata had been reported. They had investigated all cases of spinal cord tumour at the Massachusetts General Hospital and in their own practice, and had found a surprisingly large number of such lesions. In their view the majority of these protrusions were not, in fact, tumours at all but were caused by a herniation of the nucleus of an intervertebral disc. They further suggested that the treatment of this condition was surgical.

It was surprising how quickly this view found widespread acceptance. During the next 15 years a very large number of papers were published dealing with every aspect of the problem. Several contributions were of great significance. Perhaps the most noteworthy were the description of the concealed disc by Dandy[22] in 1941 and the recognition of disc lesions as the commonest cause of low back pain unassociated with sciatica by Key[23] in 1945 and by Burns and Young[24, 25] in 1945 and 1947

The past five years have seen comparatively few additions of any value to our knowledge of disc lesions Valuable suggestions have however been made regarding possible aetiological factors. The work of Charnley[26] on fluid imbibation Scott[27] on mental stress and Lindblom[28, 29] on compression not only suggests that these may play some part in the production of disc lesions but also represents a breakaway from the older and almost certainly erroneous conception of trauma as the dominant cause of disc disorders.

Since 1934 a vast amount of information about disc lesions has been accumulated It is true that a great deal remains to be discovered and that many points are still highly controversial. Nevertheless we now understand much that was previously obscure and our most urgent need is to reduce to order the somewhat chaotic accumulation of facts at our disposal.

[21] Mixter W J., & Barr J S. (1934) Rupture of the intervertebral disc with involvement of the spinal canal. *New Engl J Med.*, 211 210-215

[22] Dandy W E. (1941) Concealed ruptured intervertebral discs plea for elimination of contrast medium in diagnosis. *J Amer med Ass.*, 117 820-823

[23] Key J A (1945) Intervertebral disc lesions are most common cause of low back pain with or without sciatica. *Ann. Surg.*, 121 534 544

[24] Burns, B H & Young, R H (1945) Protrusion of intervertebral disc. *Lancet* ccxlix, 424-4 7

[25] Burns, B H & Young, R H (1947) Backache *Lancet* cclii, 623-626

Charnley John (1951) Fluid imbibation as a cause of herniation of the nucleus pulposus. *J Bone Jt Surg* 33-B, 472.

[27] Scott, J C (1955) Stress factor in the disc syndrome *J Bone Jt Surg.*, 37-B 107 111

[28] Lindblom, Kurt (195) Experimental ruptures of intervertebral disc in rats tails. *J Bone Jt Surg* 34-A 123 128

[29] Lindblom, Kurt (1957) Intervertebral disc degeneration considered as a pressure atrophy *J Bone Jt Surg* 39 A, 933-945

INTRODUCTION

When reviewing the earlier investigations into the cause of sciatica associated with low back pain it is easy to be critical It should be remembered however that this work was done without the aid of adequate radiological facilities and that surgical exploration of the spinal cord was a formidable undertaking of considerable magnitude It should also be remembered that during this time it was widely accepted that sciatica was due to peripheral lesions of the nerve itself and that this view was backed by the most influential and weighty medical opinions It is therefore all the more to the credit of those pioneers who stubbornly sought for a pathology which would explain the association between sciatica and pain in the lumbar region Moreover it is a matter of surprise not that they failed to recognise the existence of lesions of the lumbar intervertebral discs but that they came so near to the truth with the resources then available at their command

Mixter and Barr may be said to have laid the first stone in the structure of our present knowledge Nevertheless its foundations were already there having been prepared by such pioneers as Vesalius in 1555 and Dominico Cotugnio in 1764

CHAPTER II

THE ANATOMY OF THE LUMBAR INTERVERTEBRAL DISCS

IT is impossible to achieve any real understanding of the many clinical problems associated with the diagnosis and management of lumbar disc lesions without a comprehensive knowledge of the structure relations and function of the discs themselves. Every anatomical and physiological detail has some practical significance only a study of the normal can furnish the key to the complexities of the abnormal.

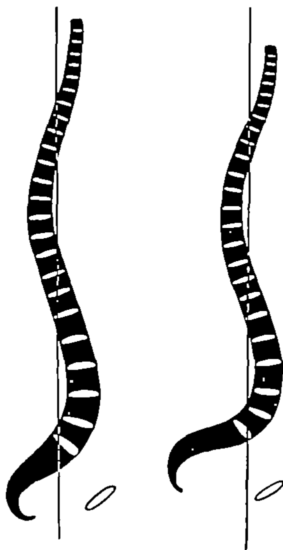


FIG. 1
The primary and secondary curves of the spinal column
The primary curves are concave forwards and lie in the embryonic axis, being due to the shape of the vertebral bodies. The secondary curves are convex forwards and are produced by the shape of the intervertebral discs.

The intervertebral discs lie between the bodies of the vertebrae of the pre sacral segments of the spinal column. The discs have a triple function they bind the vertebral bodies together they form an integral part of the intervertebral joints, permitting movement between individual vertebrae, and they transmit the body weight.

It is not surprising, therefore, that intervertebral discs have a complex and highly specialised structure. The demands made on them are of the highest order Not only must they allow movement but they must provide stability and withstand mechanical forces at least as great as any to which body tissues are subjected. Moreover they must habitually transmit the body weight, being the only structures other than bone or cartilage with this function.

Besides providing the element of flexibility the intervertebral discs have an important bearing on the length and shape of the spinal column They constitute between one-quarter and one-fifth of the total length of the spine being relatively thicker in the more mobile cervical and lumbar regions Almost one-third of the

length of the lumbar region which itself comprises one third of the pre sacral spine is made up by the lumbar discs

The discs by their shape are largely responsible for the formation of the secondary curves in the spine The primary curves of the dorsal and sacral region concave forward and corresponding to the embryonic axis, are due to the shape of the vertebral bodies, which are deeper posteriorly than anteriorly in these regions. The secondary curves are convex forward to permit the assumption of the erect position and are largely due to the shape of the intervertebral discs (Fig 1)

In the cervical region the secondary curve begins to develop during late foetal life and is produced by the cervical discs, which are deeper anteriorly than posteriorly

The secondary lumbar curve developing after birth with the extension of the legs and later with the assumption of the sitting and standing positions, is largely caused by the shape of the lumbar discs. In lower races the total depth of the anterior surface of the vertebral bodies is less than that of the posterior surface, and in such races the lumbar curve is due entirely to an increased anterior depth of the discs. In the higher races the anterior depth of the bodies is just greater than the posterior depth (Frazer[1]) but the major part of the anterior convexity is produced by the shape of the discs (Fig. 2)



FIG. 2
The lumbar spine
The lumbar curve is convex forwards and is produced mainly by the shape of the intervertebral discs which are deeper anteriorly than posteriorly

The acute lumbo-sacral angle first appears about mid foetal life This angle, which varies from individual to individual and is greater in the female than in the male, is due to a marked increase in the anterior depth of both the fifth lumbar vertebral body and the lumbo-sacral disc. This disc is on an average some two-and a half times deeper anteriorly than posteriorly (Fig. 2)

Thus, when the shape and function of the spine as a whole is considered, it is obvious that the intervertebral discs are at least as important as the vertebrae and being of soft tissue are more vulnerable and more liable to degenerative change than the solid bony vertebral bodies.

[1] Frazer J E. (1933) *The Anatomy of the Human Skeleton*, 3rd ed. London, Churchill

EARLY DEVELOPMENT OF LUMBAR VERTEBRAE AND DISCS

Developmental abnormalities may be an aetiological factor in lesions of the lower lumbar intervertebral discs. It is therefore important that the formation and subsequent growth of the discs should be clearly understood.

The embryology of the vertebral bodies and intervertebral discs has been studied exhaustively by Keyes and Compere.[1] In the early embryo mesenchymal cells of the sclerotome migrate to surround the notochord. These cells form a

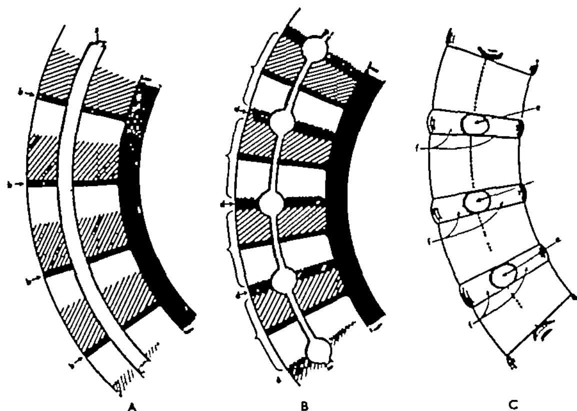


FIG. 3

The early development of the lumbar discs

Mesenchymal cells migrate to surround the notochord (a) forming a segmented column, the segments being separated by the intersegmental arteries (b), and consisting of a light cephalic and dark caudal mass (A). The cells nearest the vessels receive the best blood supply and fuse to form the precursor of the vertebral bodies (c) while the cranial parts of the dark caudal masses remain undifferentiated (d) to form part of the discs (B). Subsequently in the vertebral bodies the notochord is encroached on and notochordal cells are squeezed or migrate to the region of the discs (B). Advancing ossification later obliterates the notochord in the vertebral bodies (C). In the region of the discs the nucleus is formed by notochordal cells (e) while the remains of the dark caudal masses (f) form the annulus (C)

segmented column the segments being separated by the intersegmental arteries which are direct branches of the aorta. This column can be distinguished in a five weeks embryo and it can be observed that each segment consists of a dark caudal and a light cephalic mass (Fig. 3A)

[1] Keyes, D. C. & Compere, E. L. (1932) The normal and pathological physiology of the nucleus pulposus of the intervertebral disc. *J. Bone Jt Surg.*, 14 897-938

The cells nearest to the intersegmental vessels receive most nutrition and the cephalic and caudal masses of adjacent segments rapidly add cytoplasm and fuse to form the precursor of the vertebral body The cranial portion of each dark caudal mass that is the part of the column furthest removed from an arterial supply remains undifferentiated and forms part of the intervertebral disc (Fig. 3B)

The subsequent development of the vertebral bodies is comparatively simple With the fusion of cephalic and caudal masses of adjacent segments to form the pre-cartilaginous vertebral body the notochord in these regions becomes obliterated and notochordal cells migrate or are squeezed' into the intervertebral regions (Fig. 3B) In a ten weeks embryo the vertebral bodies consist of cartilage cells centres of ossification already being present and the site of the notochord is marked only by a mucoid streak This streak is obliterated by advancing ossifi cation and at birth the vertebral bodies consist of bone with cartilaginous end plates covering the adjacent intervertebral surfaces (Fig. 3c)

It is from the central surfaces of these cartilage plates that osseous growth by enchondral bone formation is continued until maturity

The development of the intervertebral discs is rather more complex In a ten weeks embryo the intervertebral area consists of two distinct parts The central region is composed of notochordal cells (Fig. 3B) These cells have been extruded from the vertebral areas with the obliteration of the notochord and now form the developing nucleus pulposus. It seems probable that in the growing embryo these notochordal cells actually multiply to take part in the formation of the nucleus. Keyes and Compere[3] point out that there is more notochordal tissue in the inter vertebral areas of an 18 weeks embryo than in the entire notochord of a seven and a half weeks embryo when mucoid degeneration in the vertebral area first com mences, and these authors believe that up to birth notochordal tissue remains the chief source of nucleus pulposus material. The second and peripheral part of the intervertebral area is formed by cells from the cranial portion of the dark caudal masses. These cells form the annulus fibrosus and in the ten weeks embryo are already differentiated into elongated fibroblasts. These fibroblasts are arranged around the developing nucleus being centrally attached above and below to the cartilaginous vertebral bodies around the notochordal site They are bulged out laterally by the enlarging nucleus which does not itself come into direct contact with the vertebral bodies but is separated from them by fibrocartilage arising from the intervertebral disc substance In an 18 weeks embryo the nucleus has increased in size, due to proliferation of notochordal cells, and the fibrocartilaginous annulus is well marked and already shows traces of a lamellar structure (Fig. 3c). One other change of great significance is evident at this stage. From the central part of the annulus invaginations can be seen invading the nucleus. Keyes and Compere[3] believe that this ingrowth from the annulus forms the fibrous part of the nucleus and after birth proliferation of this fibrous element is the chief source of nuclear growth. Thus the adult nucleus pulposus has a double origin being partly derived

[3] Keyes, D C., & Compere E. L. (1932) The normal and pathological physiology of the nucleus pulposus of the intervertebral disc. *J Bone Jt Surg* 14 897-938

from the notochord and partly from fibrous ingrowths from the surrounding annulus. This double origin explains the absence of any clear line of demarcation between the annulus and the nucleus in an adult disc.

Later Changes.

At birth the bony vertebral bodies have well rounded upper and lower surfaces so that they are bi-convex in shape. These surfaces are covered by cartilaginous end plates and bone growth takes place over the whole of the sub-cartilaginous area. The vertebral bodies gradually become flatter and about puberty secondary centres of ossification appear in the peripheral part of the cartilaginous end plates. From these centres ossification spreads to form a bony ring which is partially incomplete posteriorly With the cessation of vertebral growth, between the ages of 16 and 21 and earlier in the female than in the male this ring fuses with the vertebral body Centrally and posteriorly however the cartilage end plate persists unchanged This plate covers the bony surface, separating it from the nucleus pulposus, and gives attachment to the fibres of the nucleus and annulus

At birth the nucleus pulposus is mucoid containing notochordal cells and being interlaced with fine strands of fibrocartilage which originate from the annulus. As the nucleus develops the notochordal cells disappear although a few notochordal remnants are occasionally found in the adult nucleus. Growth takes place chiefly by proliferation of the fibrous element and in a four years-old child this element is prominent and frequent cartilage cells are found In the 12 years-old disc the nucleus is made up almost completely of loose fibrocartilage with an abundant gelatinous matrix The process of replacement of the gelatinous mucoid material with fibrocartilage continues throughout life and the senile disc is composed almost entirely of dense irregular fibrocartilage. The water content of the nucleus at various stages has been calculated by Püschel[4] and by Keyes and Compere.[5] The figures of these investigators agree closely at birth the water content is 88 per cent. and at 77 years it has decreased to 69 per cent.

The annulus, which is already somewhat lamellated at birth develops in accordance with the stresses to which it is subjected. The details of its adult structure vary therefore in the different segments of the spine. The water content of the annulus also varies with age. According to Püschel[4] it is 78 per cent. at birth and falls to 70 per cent. by the end of the third decade of life thereafter remaining fairly constant.

SEGMENTAL RELATIONSHIP BETWEEN DISCS AND NERVE ROOTS

From the clinical point of view it is extremely important to decide which intervertebral disc corresponds in embryonic level to each lower lumbar root. This relationship decides the site of referred deep pain, which is felt in those meso-

[4] Püschel, J (1930) Der Wassergehalt normaler und degenerierter Zwischenwirbelscheiben. *Beitr path Anat* 84, 123 130

[5] Keyes, D C & Compere E L. (1932) The normal and pathological physiology of the nucleus pulposus of the intervertebral disc *J Bone Jt Surg.*, 14 897 918

dermal elements which arise from the same embryonic level as the structure which is the source of the pain

Both the intervertebral discs and the nerve roots are segmental structures but with the growth and development of the vertebral column and the spinal cord all obvious relationship between corresponding embryonic levels is lost It is possible however to determine the segmental connection between discs and roots by a consideration of their development.

At the cranial end of the vertebral column the presence of the occipital segments greatly complicates the developmental picture At the caudal end however the position is somewhat simpler and the development of this end of the cord and vertebral column can be traced

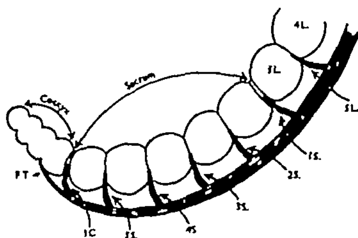


Fig. 4

Posterior end of cord and spine in a three months embryo (diagrammatic)

The spinal cord ends at the level of the first coccygeal vertebra, where the filum terminale is attached. The first coccygeal nerve corresponds in level to the sacro-coccygeal disc, the second, third, fourth and fifth sacral nerves to the potential disc spaces in the sacrum, the first sacral nerve to the L5 S1 disc and the fifth lumbar nerve to the L4 L5 disc.

Before the embryo reaches 4 mm in length the spinal cord has been laid down to its full extent and at this stage its caudal end is in a rudimentary state The cord ends in relation to or in continuity with a mass of cells which also terminate the notochord the somitic series and the prolongation from the gut. This caudal projection represents a rudimentary tail which first grows a little and then degenerates and which has disappeared completely when the embryo reaches about 18 mm. At this stage four or more nerves take origin behind the coccygeal nerve and these emerge between five or six rudimentary vertebrae which lie behind the sacrum (Frazer[4])

The post-coccygeal part of the cord and the post-coccygeal nerves do not persist as nerve tissue but ultimately form the filum terminale which becomes attached to the posterior surface of the first piece of the coccyx. The coccyx itself is developed from those rudimentary post-sacral vertebrae which persist.

At the end of the third month which is the latest period at which the spinal cord and vertebral column correspond in length the position is as shown in Figure 4 The spinal cord proper ends at the level of the first coccygeal vertebra, no true nerve tissue persisting beyond this point. The first coccygeal nerve corresponds in segmental level to the sacro-coccygeal disc. The second third fourth and fifth sacral nerves correspond to the potential discs between the five sacral

[4] Frazer J E. (1931) *Manual of Embryology* 136-139 London Baillière, Tindall & Cox.

segments, and the first sacral and fifth lumbar roots correspond in segmental level to the L.5 S.1 and L.4 L.5 discs.

The subsequent disparity of growth between the column and cord does not alter this segmental relationship

From the segmental point of view therefore the L.5 S 1 disc and mesodermal elements in the legs supplied by the first sacral nerve root are of the same embryonic level and the same is true of the L.4 L.5 disc and the structures supplied by the fifth lumbar nerve roots. Deep or sclerotogenous pain originating from these discs would if referred to the legs, be felt mainly in the muscle groups supplied by the corresponding roots

THE STRUCTURE OF THE ADULT LUMBAR DISC

The adult disc is best considered as consisting of three parts the cartilage plates enclosing it above and below the nucleus pulposus, and the annulus fibrosus.

The cartilage plates cover the central part of the vertebral body Anteriorly and laterally they abut on the bony epiphyseal ring which has been described already while posteriorly they may extend to the margin of the vertebral body The fibres of the annulus and nucleus take origin from, and are very intimately blended with the peripheral part of this cartilage plate.

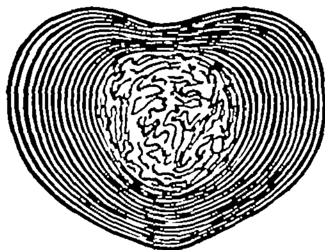


FIG. 5

Section of a lumbar disc (diagrammatic)

The annulus consists of between ten and twelve concentric lamellae. Anteriorly and posteriorly these are fine and closely packed while laterally they are thicker and more widely spaced The central nucleus is composed of a loose network of fine connective tissue in the meshes of which lie many spindle-shaped cells and cartilage cells.

The adult nucleus pulposus is of a semi-gelatinous consistency and is white, glistening and slightly translucent. Microscopically it is composed of a loose network of fine strands of fibrous tissue. These fibrous strands are arranged irregularly and run in bundles with a wavy course. On the upper and lower surface of the nucleus these bundles lie at an acute angle to the cartilage plates, into which they sink and have firm attachment. In the meshes of the fibrous tissue are many spindle-shaped connective tissue cells and cartilage cells. In the lumbar region the nucleus is situated rather behind the centre of the disc. The whole nucleus is highly plastic, obeys the law of fluids and is held in shape by the surrounding annulus and cartilage plates.

The annulus fibrosus in the lumbar region consists of a series of concentric lamellae whose fibres pass obliquely from their attachment to the cartilage plates

and epiphyseal rings of adjacent vertebral bodies The fibres of the various lamellae lie at an angle to each other an arrangement which increases the strength of the intervertebral attachments In the lumbar region there are between 10 and 12 such lamellae which anteriorly and posteriorly are fine and packed closely together while laterally they become much thicker and widely spaced and spread over a much larger area (Fig. 5). Between the lamellae there is loose fibrous tissue. At the anterior and lateral margins of the vertebral body the annulus is very firmly attached to the epiphyseal ring and the anterior part of the annulus blends intimately with the powerful anterior common ligament and through it gains attachment to the anterior surface of the vertebral bodies Posteriorly however the peripheral attachment is not nearly so firm Here the annulus is looser both in itself and in its attachments and the posterior common ligament with which it blends is a relatively weak structure (Beadle[7]) The annulus binds the vertebral bodies together but because of its lamellated structure and the direction of its fibres permits a certain amount of movement between the individual vertebrae. The annulus also serves as a retaining envelope for the elastic nucleus by which it is slightly distended

There is no clear line of demarcation between the annulus and nucleus These structures merge one into the other and with increasing age the difference between annulus and nucleus becomes progressively less distinct. It should be remembered that in the lower lumbar region the nucleus constitutes rather less than one-quarter of the total volume of the disc.

THE NUTRITION OF THE INTERVERTEBRAL DISCS

One of the characteristic features of the intervertebral discs at all stages of maturity is that they appear to contain no true blood vessels

Keyes and Compere[8] have pointed out that the discs develop from the cephalic end of the dark caudal mass of each perinotochordal segment and that this area is the farthest removed from the intersegmental arteries. These authors suggest that the discs are completely avascular from their earliest stages and that their nourishment is effected by filtration of lymph.

Übermuth[9] on the other hand, has described a blood supply to the cartilage end plates during their development. He states that there is a circle of vessels round the cartilage plate with central capillaries containing only lymph in the plate itself These vessels arise from the marrow of the vertebral body and run perpendicularly giving off radial communicating branches and arches running peripherally to join the periosteal vessels. This blood supply is present in the embryo and is gradually obliterated during the first twenty years of life. Übermuth s

[7] Beadle, O A. (1931) *The Intervertebral Disc: Observation on their Normal and Morbid Anatomy in relation to Certain Spinal Deformities* 14 London H M.S.O

[8] Keyes, D C., & Compere E. L. (1932) The normal and pathological physiology of the nucleus pulposus of the intervertebral disc. *J Bone Jt Surg.,* 14 897 938

[9] Übermuth, H (1929) Über die Altersveränderungen der menschlichen Zwischenwirbelscheibe und ihre Beziehung zu den chronischen Gelenkleiden der Wirbelsäule *Ber Verh Sächs. Acad Wissensch., Leipzig* Math Phys. Klasse 81 111

work was confirmed by a later and very thorough investigation by Böhmig,[10] and Smith[11] in 1931 described nutritive channels in the intervertebral discs. Although these channels have no endothelial lining Smith considers that they are in fact blood vessels. The investigations of Coventry Ghormeley and Kernshaw[12] also appear to support the existence of vascular channels during the first three decades of life

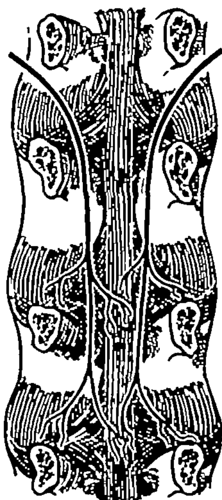


FIG. 6
Nervus sinuvertebralis of Von Luschka
This nerve arises from the posterior primary division of one root, re-enters the canal through the foramen and supplies the posterior longitudinal ligament and the posterior part of the annulus of the discs two segments below its origin.

The adult intervertebral disc is completely avascular and its nutrition is maintained by diffusion through the cartilage end plates The bone of the vertebral bodies deep to the cartilage plate has a characteristic structure with a central area of compact bone perforated by numerous minute holes and a peripheral less compact area with larger perforations. Through these apertures lymph is diffused from the marrow cavity of the vertebra to the cartilage plates and intervertebral discs.

It has been suggested that nutrition by a scanty supply of lymph diffused through many minute apertures is an inefficient arrangement and that the absence of a free blood supply accounts for the liability of the discs to degeneration in later life It seems probable, however that the exact reverse is true and that avascularity is one of the essential characteristics of cartilage or fibrous tissue in contact with weight bearing surfaces (Watson Jones[13])

NERVE SUPPLY OF THE LUMBAR INTERVERTEBRAL DISCS

It was formerly stated that the intervertebral discs contained no nerve endings (Jung and Brunschwig[14]) In 1940 however Roofe[15] was able to demonstrate many unmyelinated nerve fibres in the tissue of the posterior part of the

[10] Bohmig, R. (1930) Die Blutgefässversorgung der Wirbelbandscheiben, das Verhalten des intervertebralen Chordasegmentes und die Bedeutung beider für die Bandscheibendegeneration. *Arch Klin. Chir.*, 158, 374
[11] Smith, W R (1931) The intervertebral discs. *Brit J Surg* 18, 358 375
[12] Coventry M B., Ghormeley R K., & Kernshaw J W (1945) The Intervertebral disc its microscopic anatomy and pathology Part I Anatomy development and physiology *J Bone Jt Surg* 27 105-112.
[13] Watson Jones R (1948) Robert Jones Memorial Lecture, Royal College of Surgeons.
[14] Jung, A & Brunschwig, A. (1932) Recherches histologiques sur l'Innervation des corps vertebraux *Pr méd* 40, 316-317
[15] Roofe, P C (1939) Innervation of annulus fibrosus and posterior longitudinal ligament. *Arch Path* 27 01 -11

annulus fibrosus. These fibres terminated in naked nerve endings within the annulus and there were a few similar fibres in the posterior longitudinal ligament Roofe attempted to trace the origin of these fibres and found nerve strands originating beyond the dorsal root ganglia re-entering the vertebral canal through the foramina. These fibres probably correspond to the recurrent branches of the spinal nerves described by von Luschka[16] in 1858 This recurrent nerve the nervus sinu vertebralis, was said to arise from the posterior primary division after the roots have left the intervertebral foramen re-enter the canal and descend in the extradural tissue to be distributed to the posterior longitudinal ligament and posterior aspects of the intervertebral discs for two segments below its origin (Fig 6)

Recently the course and distribution of the sinu vertebral nerves have been further studied by Pedersen Blunck and Gardner [17] They attempted to trace the distribution of the posterior rami and the sinu vertebral branches of the spinal nerves by dissection of newborn and adult cadavera Their findings suggest that the posterior rami in addition to their cutaneous and muscular distributions give sensory fibres to fascia ligaments, periosteum and posterior intervertebral joints, and that adjacent divisions overlap in their area of supply The sinu vertebral nerves were traced from their origin from the spinal nerves just distal to the ganglion either close to or in conjunction with the ramus communicans The nerve re-enters the spinal canal, curves upwards around the base of the pedicle and proceeds towards the midline giving off branches ascending towards the disc above and others descending across the disc below Filaments supply the posterior longitudinal ligament, periosteum blood vessels and dura mater In adult cadavera the filaments broke before their endings could be traced but in foetal material it was possible to demonstrate anastomoses with the nerves above and below Fibres could be traced to the margin of the annulus fibrosus but none was demonstrated within the annulus itself These authors found no nerves having only a downwards course (Fig 7)



FIG. 7
Sinu vertebral nerve (Diagrammatic representation after Pedersen, Blunck and Gardner) The nerve re-enters the canal, curls upward around the pedicle and breaks into ascending branches running towards the disc above and descending branches crossing the disc below Adjacent nerves anastomose with each other and there is probably an anastomosis across the middle line.

THE LUMBAR INTERVERTEBRAL JOINTS

The intervertebral joints consist of two parts the anterior amphiarthrodial articulation between the vertebral bodies and the posterior arthrodial joints between the articular processes of the vertebrae (Fig. 8)

The anterior joints depend on the intervertebral discs for their function and the structure of the discs as already described permits a small range of movement

[16] Von Luschka, H (1858) *Die Halbgelenke des menschlichen Korpers.* Vol 4 Berlin, G Reimer

[17] Pedersen H E., Blunck, C. F J., & Gardner E. (1956) The anatomy of lumbosacral posterior rami and meningeal branches of spinal nerves (sinu vertebral nerves). *J Bone Jt Surg* 38-A, 377 391

work was confirmed by a later and very thorough investigation by Böhmig.[10] and Smith[11] in 1931 described nutritive channels in the intervertebral discs. Although these channels have no endothelial lining, Smith considers that they are in fact blood vessels. The investigations of Coventry Ghormeley and Kernshaw[12] also appear to support the existence of vascular channels during the first three decades of life.

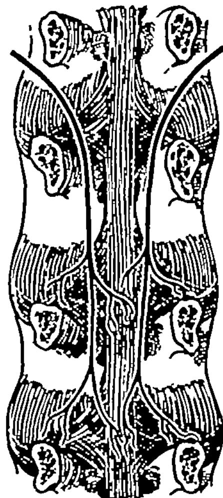


FIG. 6
Nervus sinuvertebralis of Von Luschka
This nerve arises from the posterior primary division of one root, re-enters the canal through the foramen and supplies the posterior longitudinal ligament and the posterior part of the annulus of the discs two segments below its origin.

The adult intervertebral disc is completely avascular and its nutrition is maintained by diffusion through the cartilage end plates The bone of the vertebral bodies deep to the cartilage plate has a characteristic structure with a central area of compact bone perforated by numerous minute holes and a peripheral less compact area with larger perforations. Through these apertures lymph is diffused from the marrow cavity of the vertebra to the cartilage plates and intervertebral discs.

It has been suggested that nutrition by a scanty supply of lymph diffused through many minute apertures is an inefficient arrangement and that the absence of a free blood supply accounts for the liability of the discs to degeneration in later life. It seems probable, however that the exact reverse is true and that avascularity is one of the essential characteristics of cartilage or fibrous tissue in contact with weight-bearing surfaces (Watson Jones[13]).

NERVE SUPPLY OF THE LUMBAR INTERVERTEBRAL DISCS

It was formerly stated that the intervertebral discs contained no nerve endings (Jung and Brunschwig[14]) In 1940 however Roofe[15] was able to demonstrate many unmyelinated nerve fibres in the tissue of the posterior part of the

[10] Böhmig, R. (1930) Die Blutgefässversorgung der Wirbelbandscheiben, das Verhalten des intervertebralen Chordasegmentes und die Bedeutung beider für die Bandscheibendegeneration. *Arch klin Chir.*, 158, 374
[11] Smith, W R (1931) The intervertebral discs. *Brit J Surg* 18, 358 375
Coventry M B., Ghormeley R. K., & Kernshaw J W (1945) The Intervertebral disc its microscopic anatomy and pathology Part I, Anatomy development and physiology *J Bone Jt Surg* 27 105-112.
[13] Watson-Jones R (1948) Robert Jones Memorial Lecture, Royal College of Surgeons.
[14] Jung, A & Brunschwig, A. (1932) Recherches histologiques sur l'innervation des corps vertebraux *Pr méd.*, 40, 316-317
[15] Roofe P C (1939) Innervation of annulus fibrosus and posterior longitudinal ligament. *Arch Path* 27 201 211

annulus fibrosus. These fibres terminated in naked nerve endings within the annulus and there were a few similar fibres in the posterior longitudinal ligament Roofe attempted to trace the origin of these fibres and found nerve strands originating beyond the dorsal root ganglia re-entering the vertebral canal through the foramina These fibres probably correspond to the recurrent branches of the spinal nerves described by von Luschka[14] in 1858 This recurrent nerve the nervus sinu vertebralis, was said to arise from the posterior primary division after the roots have left the intervertebral foramen re-enter the canal and descend in the extradural tissue to be distributed to the posterior longitudinal ligament and posterior aspects of the intervertebral discs for two segments below its origin (Fig 6)

Recently the course and distribution of the sinu vertebral nerves have been further studied by Pedersen Blunck and Gardner[17] They attempted to trace the distribution of the posterior rami and the sinu vertebral branches of the spinal nerves by dissection of newborn and adult cadavera Their findings suggest that the posterior rami, in addition to their cutaneous and muscular distributions, give sensory fibres to fascia ligaments, periosteum and posterior intervertebral joints, and that adjacent divisions overlap in their area of supply The sinu vertebral nerves were traced from their origin from the spinal nerves just distal to the ganglion either close to or in conjunction with the ramus communicans. The nerve re-enters the spinal canal, curves upwards around the base of the pedicle and proceeds towards the midline giving off branches ascending towards the disc above and others descending across the disc below Filaments supply the posterior longitudinal ligament, periosteum blood vessels and dura mater In adult cadavera the filaments broke before their endings could be traced but in foetal material it was possible to demonstrate anastomoses with the nerves above and below Fibres could be traced to the margin of the annulus fibrosus but none was demonstrated within the annulus itself These authors found no nerves having only a downwards course (Fig 7)



FIG 7
Sinu vertebral nerve. (Diagrammatic representation after Pedersen, Blunck and Gardner) The nerve re-enters the canal, curls upward around the pedicle and breaks into ascending branches running towards the disc above and descending branches crossing the disc below Adjacent nerves anastomose with each other and there is probably an anastomosis across the middle line

THE LUMBAR INTERVERTEBRAL JOINTS

The intervertebral joints consist of two parts the anterior amphiarthrodial articulation between the vertebral bodies and the posterior arthrodial joints between the articular processes of the vertebrae (Fig 8)

The anterior joints depend on the intervertebral discs for their function and the structure of the discs as already described permits a small range of movement

[14] Von Luschka, H. (1858) *Die Halbgelenke des menschlichen Korpers* Vol. 4 Berlin, G Reimer

[17] Pedersen, H E., Blunck C. F J., & Gardner E. (1956) The anatomy of lumbosacral posterior rami and meningeal branches of spinal nerves (sinu-vertebral nerves). *J Bone Jt Surg.*, 38-A, 377 391

between the individual vertebral bodies Anteriorly the discs are reinforced by the anterior longitudinal ligament, a strong fibrous band which extends from the pharyngeal tubercle of the occiput to the upper part of the anterior surface of the sacrum In the lumbar region it is a stout, powerful structure which increases a little in width from above downwards. It is firmly attached to the anterior surfaces of the vertebral bodies, and opposite the intervertebral areas it blends with the superficial fibres of the anterior part of the annulus fibrosus.

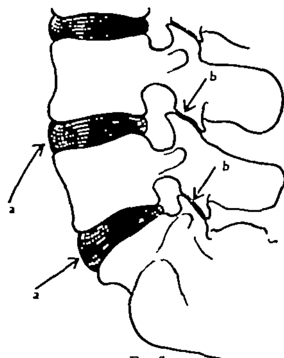


FIG. 8

The intervertebral articulations

Each intervertebral joint consists of two parts, an anterior amphiarthrodial joint between the vertebral bodies (a) and two posterior arthrodial joints between the *articular processes (b).*

The bony elements of the posterior joints are the articular processes which arise from the neural arches In the lumbar *region the neural arches have a character*istic structure Stout pedicles arise from the upper two-thirds of the vertebral bodies and join the strong laminae which are about as deep as the bodies. The spinous processes project directly back ward and are quadrilateral in shape, and the transverse processes are comparatively slender and arise from the lateral surface of the pedicles The articular processes, which arise from the junction of pedicles and laminae behind the transverse processes, are almost vertical. The articular facets on the superior processes are concave, whilst those on the inferior processes are convex The actual plane of the posterior articulations has an impor tant effect on intervertebral movement. In the dorsal region the plane of the articulations lies in the axis of rotation of the vertebral bodies one on the other while in the lumbar and cervical regions the plane of the articulation lies across this axis and prevents rotation taking place in these regions

In the lumbar region the articular facets with the exception of those of the lumbo-sacral joint lie more or less in the sagittal plane The lumbo-sacral articular facets on the other hand lie more in the coronal plane. There are however many variations from this arrangement and the direction of the facets is often irregular *and may even differ on the two sides*

The articular capsules of the posterior joints are thin and loose and are attached just beyond the margins of the articular surfaces. These joints are reinforced by several powerful ligaments. The ligamenta flava comprised of yellow elastic *tissue with fibres running in the vertical direction connect the laminae* of adjacent vertebrae. The laminae lie obliquely passing downward and outward from their superior margins. Each ligamentum flavum arises from the upper third of the

posterior surface of the upper margin of the lamina below and is attached to the upper half of the anterior surface of the lamina above Posteriorly the ligaments on each side are in contact and are to some extent fused The anterior edge of each ligament does not blend with the joint capsule but lies free in the back of the intervertebral foramen and forms the posterior relation of the issuing nerve (Fig 9) The interspinous ligaments connect the spinous processes and in the lumbar region these ligaments are thick and quadrilateral Anteriorly they come into contact with the posterior margins of the ligamenta flava while posteriorly they blend with the supraspinous ligament a strong fibrous cord which connects the apices of the spinous processes (Fig 9)

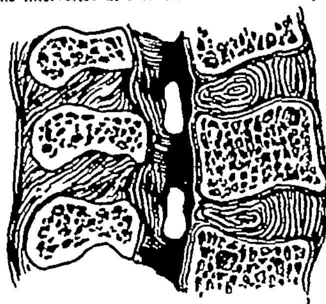


Fig. 9
Cross-section of vertebral column showing ligaments and intervertebral foraminae.

THE ANATOMICAL RELATIONS OF THE LUMBAR INTERVEREBRAL DISCS

Lesions of the lumbar intervertebral discs may in certain circumstances, involve adjacent structures The immediate relationships of the disc are, therefore, of surgical significance

The upper and lower disc surfaces are in contact with the central cartilage plate and peripheral epiphyseal ring of the corresponding surfaces of the vertebral bodies Deep to the cartilage plate the cancellous bone of the vertebral bodies shows a central circular area of compact bone corresponding in position to the nucleus pulposus. This plate is perforated by numerous minute holes and is surrounded by a much looser bone in which the perforations are larger (Beadle[11]).

The anterior surfaces of the vertebral bodies and discs form the central part of the posterior abdominal wall. The anterior common ligament, a strong fibrous band which increases in width from above downwards covers and is attached to both vertebral bodies and discs. The crura of the diaphragm take origin from the lateral aspects of the anterior surfaces on the right side from the upper three and on the left from the upper two bodies and discs The most important anterior relations of the discs are, however the great vessels. The aorta lying on the left side of the midline is in contact with the upper three discs and bifurcates at the level of the lower part of the body of the fourth lumbar vertebra The left common iliac artery is in contact with the anterior surface of the fourth lumbar disc on the left of the midline. The inferior vena cava lying in contact with the aorta and

[11] Beadle O A. (1931) *The Intervertebral Discs Observation on their Normal and Morbid Anatomy in relation to Certain Spinal Deformities* London H M S O

between the individual vertebral bodies. Anteriorly the discs are reinforced by the anterior longitudinal ligament a strong fibrous band which extends from the pharyngeal tubercle of the occiput to the upper part of the anterior surface of the sacrum In the lumbar region it is a stout, powerful structure which increases a little in width from above downwards It is firmly attached to the anterior surfaces of the vertebral bodies, and opposite the intervertebral areas it blends with the superficial fibres of the anterior part of the annulus fibrosus.

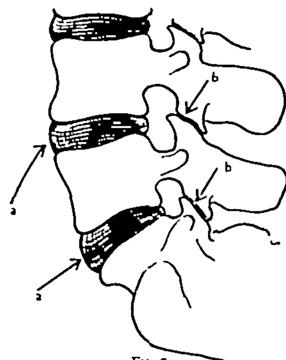


FIG. 8
The Intervertebral articulations
Each intervertebral joint consists of two parts, an anterior amphiarthrodial joint between the vertebral bodies (a) and two posterior arthrodial joints between the articular processes (b)

The bony elements of the posterior joints are the articular processes which arise from the neural arches In the lumbar region the neural arches have a characteristic structure. Stout pedicles arise from the upper two-thirds of the vertebral bodies and join the strong laminae which are about as deep as the bodies. The spinous processes project directly backward and are quadrilateral in shape and the transverse processes are comparatively slender and arise from the lateral surface of the pedicles. The articular processes, which arise from the junction of pedicles and laminae behind the transverse processes, are almost vertical The articular facets on the superior processes are concave, whilst those on the inferior processes are convex. The actual plane of the posterior articulations has an important effect on intervertebral movement. In the dorsal region the plane of the articulations lies in the axis of rotation of the vertebral bodies one on the other while in the lumbar and cervical regions the plane of the articulation lies across this axis and prevents rotation taking place in these regions

In the lumbar region the articular facets with the exception of those of the lumbo-sacral joint lie more or less in the sagittal plane. The lumbo-sacral articular facets on the other hand lie more in the coronal plane There are however many variations from this arrangement and the direction of the facets is often irregular and may even differ on the two sides.

The articular capsules of the posterior joints are thin and loose and are attached just beyond the margins of the articular surfaces. These joints are reinforced by several powerful ligaments. The ligamenta flava comprised of yellow elastic tissue with fibres running in the vertical direction connect the of vertebrae The laminae lie obliquely passing down superior margins Each ligamentum flavum arises

posterior surface of the upper margin of the lamina below and is attached to the upper half of the anterior surface of the lamina above. Posteriorly the ligaments on each side are in contact and are to some extent fused The anterior edge of each ligament does not blend with the joint capsule but lies free in the back of the intervertebral foramen and forms the posterior relation of the issuing nerve (Fig 9) The interspinous ligaments connect the spinous processes and in the lumbar region these ligaments are thick and quadrilateral An teriorly they come into contact with the posterior margins of the liga menta flava while posteriorly they blend with the supraspinous liga ment a strong fibrous cord which connects the apices of the spinous processes (Fig 9)



Fig 9
Cross-section of vertebral column showing ligaments and intervertebral foraminae

THE ANATOMICAL RELATIONS OF THE LUMBAR INTERVEREBRAL DISCS

Lesions of the lumbar interverte bral discs may in certain circum stances, involve adjacent structures. The immediate relationships of the disc are, therefore, of surgical significance

The upper and lower disc surfaces are in contact with the central cartilage plate and peripheral epiphyseal ring of the corresponding surfaces of the vertebral bodies. Deep to the cartilage plate the cancellous bone of the vertebral bodies shows a central circular area of compact bone corresponding in position to the nucleus pulposus This plate is perforated by numerous minute holes and is surrounded by a much looser bone in which the perforations are larger (Beadle[11])

The anterior surfaces of the vertebral bodies and discs form the central part of the posterior abdominal wall The anterior common ligament, a strong fibrous band which increases in width from above downwards covers and is attached to both vertebral bodies and discs The crura of the diaphragm take origin from the lateral aspects of the anterior surfaces on the right side from the upper three and on the left from the upper two bodies and discs The most important anterior relations of the discs are, however the great vessels. The aorta, lying on the left side of the midline is in contact with the upper three discs and bifurcates at the level of the lower part of the body of the fourth lumbar vertebra. The left common iliac artery is in contact with the anterior surface of the fourth lumbar disc on the left of the midline. The inferior vena cava lying in contact with the aorta and

[11] Beadle O A. (1931) *The Intervertebral Discs: Observation on their Normal and Morbid Anatomy in relation to Certain Spinal Deformities* London, H M S O

on the right side of the midline is formed by the junction of the common iliac veins at the level of the upper part of the body of the fifth lumbar vertebra. The posterior surface of the lower end of this vessel is, therefore in contact with the anterior surfaces of the upper four lumbar discs. The levels of bifurcation of the aorta and junction of the common iliac veins vary slightly so that the exact relationship between the fourth lumbar disc and these vessels is somewhat inconstant. The anterior surface of the fifth lumbar disc is not in contact with the great vessels but is crossed by the sacral artery and veins and the pre sacral plexus, a somewhat irregular band of autonomic nerve fibres (Fig 10)

The lateral surfaces of all the lumbar discs are in contact with the psoas muscles These muscles arise from the anterior surfaces of the trans verse processes of the lumbar vertebrae and from the lateral surfaces and ad jacent areas of the vertebral bodies of the twelfth thoracic and upper four lumbar discs.

Surgically the most important relationships of the lower lumbar discs are posteriorly where they are in contact with the contents of the spinal canal and postero-laterally where they form one of the boundaries of the spinal foramina

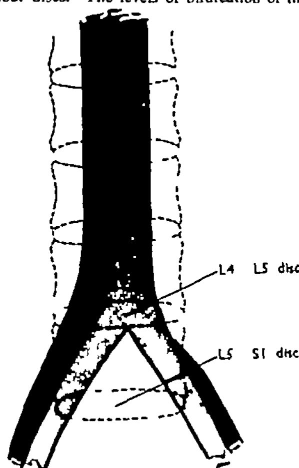


FIG. 10
Diagrammatic representations of relationship between the anterior surfaces of the lower lumbar discs and the great vessels.

THE LUMBAR SPINAL CANAL AND ITS CONTENTS

In the lumbar region both the shape and size of the spinal canal normally vary a little from individual to individual These variations are of great surgical importance being one of the major factors which determine the nature and severity of the symptoms which occur when nuclear material becomes displaced posteriorly through an annular rupture Although it is usually described as being roughly triangular the canal may vary between oval or round triangular and trefoil or clover leaf in shape (Fig. 11). The latter is of particular significance in the produc tion of root compression in association with disc protrusions and it is this variation in shape which is responsible for reports of the so-called lateral recess of the

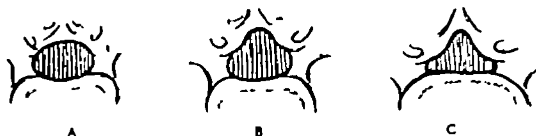


FIG. 11
Variations in shape of the spinal canal
On cross-section the canal may be round or oval (A) triangular (B) or clover leaf (trefoil) (C)

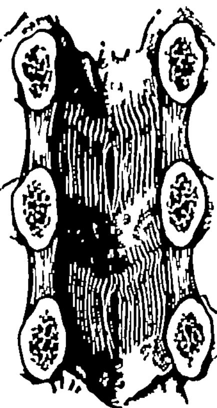


FIG. 12

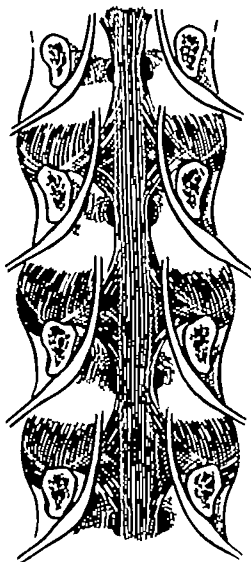


FIG. 13

FIG. 12.—The inner surface of the posterior wall of the spinal canal. The ligamenta flava cover most of the deep surfaces of the bony laminae

FIG. 13.—The anterior surface of the spinal canal showing the relationship between the roots in their extrathecal course and the posterior surfaces of the intervertebral discs and posterior longitudinal ligament

canal in the lower lumbar region (Schlesinger).[19] The size of the canal also varies a little not necessarily in direct proportion to the size of the individual as a whole and again this is a factor in the mechanism of symptom production. Occasionally definite strictures occur and these may be present in the lumbar region While the more extreme forms are associated with symptoms the minor forms may pass unnoticed (Sarpyener [20] Verbeist[21]).

Posteriorly the canal is roofed by the ligamenta flava and the laminae. Because of their obliquity only the upper third of the anterior surfaces of the laminae are *in immediate relationship to the canal the rest of the posterior wall* consisting of the ligamenta flava. In the middle line these ligaments meet and fuse with each other to some extent the junctions being covered by the overlying inter spinous ligaments (Fig. 12)

The lateral walls of the canal are formed by the ligamenta flava the posterior intervertebral joints and the pedicles. Below each pedicle and in front of the posterior intervertebral joints lie the intervertebral foramina.

The anterior wall of the canal is formed by the vertebral bodies and the posterior surface of the intervertebral discs, covered by the posterior longitudinal ligament (Fig. 13).

The major part of the canal is occupied by the spinal meninges and their contents the cerebrospinal fluid and the nerves of the cauda equina. The theca is everywhere in contact with the walls of the canal, being surrounded by a varying amount of extrathecal fat and by loose areolar tissue In this tissue lie the spinal arteries and veins and the nerves in their extrathecal course.

The relations of the nerve roots are extremely important (Fig 13). After leaving the theca the roots run for some distance in the spinal canal before *passing through the intervertebral foramina.* They *pierce* the anterior wall of the theca a little to each side of the middle line and opposite the lower parts of the vertebral bodies one segment above their respective foramina. The roots then run downward and lateralwards crossing the lateral third of the posterior surface of the disc below the body opposite which they have emerged Having crossed the disc they lie on the upper part of the posterior surface of the body below and turn outwards below the pedicle to enter the intervertebral foramen. In the extra thecal part of their *interspinal course the nerves therefore occupy an anterior* position in the spinal canal and are in the most intimate contact with the posterior surface of one intervertebral disc.

The point of emergence from the theca of the fifth lumbar and first sacral roots in relation to the L.4 L.5 and L.5 S.1 discs appears to be fairly constant that is the roots emerge just above the level of the discs. The fourth lumbar root appears to emerge just about the upper edge of the L.3 L.4 disc and in the experience of the author this relationship is constant. *It has been definitely stated* however

Schlesinger P T (1955) Incarceration of the first sacral nerve in a lateral bony recess [illegible] the spinal canal as a cause of sciatica. *J Bone Jt Surg.*, 37 A, 115 124
Sarpyener Munir Ahmed (1943) Congenital stricture of the spinal canal. *J Bone Jt Surg* 27 [illegible]0-79
Verbeist H (1954) A radicular syndrome from developmental narrowing of the lumbar [illegible]nal *J Bone Jt Surg* 36-B, 230-237

(Falconer McGeorge and Begg[22]) that the roots above the fifth lumbar arise below and are not in relationship to the discs.

The extrathecal venous plexus forms part of the intricate vertebral venous plexus. The intraspinal plexus runs mainly in the vertical direction and consists of four longitudinal veins or groups of veins two in front and two behind The anterior veins lie rather laterally on the posterior surface of the vertebral bodies and discs on each side of the posterior longitudinal ligaments The posterior veins lie close to the middle line and are in contact with the ligamentum flavum The anterior and posterior veins communicate freely with each other by a series of venous rings which are placed opposite the vertebral bodies. Some branches between the anterior veins lie deep to the posterior longitudinal ligament and communicate freely with the basivertebral plexus in the vertebral bodies. The whole internal plexus communicates freely with the external vertebral venous plexus and with the intrathecal spinal veins.

The spinal branches of the posterior rami of the lumbar arteries enter the spinal canal through the foramina. These vessels supply the canal and its contents and anastomose freely with each other and with the vessels of the opposite side.

THE LUMBAR INTERVERTEBRAL FORAMINA

The lumbar foramina are the apertures through which the lumbar roots leave the spinal canal. They may be described as being roughly quadrilateral in shape (Fig. 9) and decrease in size from above downwards. The upper and lower boundaries are formed by the vertebral pedicles the anterior walls are formed by the postero-lateral aspect of the vertebral bodies and the intervertebral discs. The posterior boundaries are the articular processes forming the posterior intervertebral joints. The lateral edge of each ligamentum flavum does not however blend with the capsule of the joints and the free lateral edge of this ligament forms part of the posterior boundary of each foramen

The issuing nerves traverse the foramina rather obliquely from above downwards. The anterior relation of each nerve as it enters the foramen is the vertebral body and the nerve only comes in contact with the postero-lateral surface of the intervertebral disc as is leaves the foramen

COMMON VARIATIONS FROM THE NORMAL

Although the foregoing is a description of the usual anatomy of the lumbar discs and the structures which surround them there are many major and minor variations from the normal Some of these such as the number of mobile vertebrae in the lumbar region the plane of the articular facets in the posterior intervertebral joints the root-disc relationship a pre or a post fixed lumbar plexus or abnormalities of the lumbar roots in their extrathecal intraspinal course affect the clinical picture associated with disc lesions These abnormalities are discussed in later sections of this book.

[22] Falconer M A., McGeorge M., & Begg, A. C (1948) Observations on the cause and mechanism of symptom production in sciatica and low back pain *J Neurol., Neurosurg Psychiat.*, 11 13-26

canal in the lower lumbar region (Schlesinger).[14] The size of the canal also v a little not necessarily in direct proportion to the size of the individual as a w and again this is a factor in the mechanism of symptom production. Occasio definite strictures occur and these may be present in the lumbar region \ the more extreme forms are associated with symptoms the minor forms may unnoticed (Sarpyener [15] Verbeist[16]).

Posteriorly the canal is roofed by the ligamenta flava and the lam Because of their obliquity only the upper third of the anterior surfaces o laminae are in immediate relationship to the canal the rest of the posterior consisting of the ligamenta flava. In the middle line these ligaments meet and with each other to some extent the junctions being covered by the overlying i spinous ligaments (Fig. 12).

The lateral walls of the canal are formed by the ligamenta flava the post intervertebral joints and the pedicles. Below each pedicle and in front o posterior intervertebral joints lie the intervertebral foramina.

The anterior wall of the canal is formed by the vertebral bodies and posterior surface of the intervertebral discs covered by the posterior longitu ligament (Fig. 13).

The major part of the canal is occupied by the spinal meninges and contents, the cerebrospinal fluid and the nerves of the cauda equina The the everywhere in contact with the walls of the canal being surrounded by a va amount of extrathecal fat and by loose areolar tissue. In this tissue lie the s arteries and veins and the nerves in their extrathecal course.

The relations of the nerve roots are extremely important (Fig. 13). / leaving the theca the roots run for some distance in the spinal canal b passing through the intervertebral foramina. They pierce the anterior wall o theca a little to each side of the middle line and opposite the lower parts of vertebral bodies one segment above their respective foramina. The roots then downward and lateralwards crossing the lateral third of the posterior surfac the disc below the body opposite which they have emerged Having crossed disc they lie on the upper part of the posterior surface of the body below turn outwards below the pedicle to enter the intervertebral foramen In the e thecal part of their interspinal course the nerves therefore occupy an ant position in the spinal canal and are in the most intimate contact with the poste surface of one intervertebral disc.

The point of emergence from the theca of the fifth lumbar and first sacral n in relation to the L.4 L.5 and L.5 S.1 discs appears to be fairly constant th the roots emerge just above the level of the discs The fourth lumbar root app to emerge just about the upper edge of the L.3 L.4 disc and in the experi of the author this relationship is constant. It has been definitely stated how

Schlesinger P T (1955) Incarceration of the first sacral nerve in a lateral bony re t the spin l canal as a cause of sciatica. *J Bone Jt Surg.*, 37 A, 115-1 4
Sarpyener Munir Ahmed (1943) Congenital stricture of the spinal canal *J B ne Surg* 27 70-79
Verbiest H (1954) A radicular syndrome from developmental narrowing of the lum nal *J Bone Jt Surg* 36-B, 230-237

(Falconer McGeorge and Begg[11]) that the roots above the fifth lumbar arise below and are not in relationship to the discs

The extrathecal venous plexus forms part of the intricate vertebral venous plexus. The intraspinal plexus runs mainly in the vertical direction and consists of four longitudinal veins or groups of veins two in front and two behind The anterior veins lie rather laterally on the posterior surface of the vertebral bodies and discs on each side of the posterior longitudinal ligaments The posterior veins lie close to the middle line and are in contact with the ligamentum flavum The anterior and posterior veins communicate freely with each other by a series of venous rings which are placed opposite the vertebral bodies Some branches between the anterior veins lie deep to the posterior longitudinal ligament and communicate freely with the basivertebral plexus in the vertebral bodies The whole internal plexus communicates freely with the external vertebral venous plexus and with the intrathecal spinal veins.

The spinal branches of the posterior rami of the lumbar arteries enter the spinal canal through the foramina These vessels supply the canal and its contents and anastomose freely with each other and with the vessels of the opposite side

THE LUMBAR INTERVERTEBRAL FORAMINA

The lumbar foramina are the apertures through which the lumbar roots leave the spinal canal They may be described as being roughly quadrilateral in shape (Fig. 9) and decrease in size from above downwards. The upper and lower boundaries are formed by the vertebral pedicles, the anterior walls are formed by the postero-lateral aspect of the vertebral bodies and the intervertebral discs The posterior boundaries are the articular processes forming the posterior intervertebral joints. The lateral edge of each ligamentum flavum does not, however blend with the capsule of the joints and the free lateral edge of this ligament forms part of the posterior boundary of each foramen

The issuing nerves traverse the foramina rather obliquely from above downwards. The anterior relation of each nerve as it enters the foramen is the vertebral body and the nerve only comes in contact with the postero-lateral surface of the intervertebral disc as is leaves the foramen

COMMON VARIATIONS FROM THE NORMAL

Although the foregoing is a description of the usual anatomy of the lumbar discs and the structures which surround them there are many major and minor variations from the normal. Some of these such as the number of mobile vertebrae in the lumbar region the plane of the articular facets in the posterior intervertebral joints the root-disc relationship a pre or a post fixed lumbar plexus or abnormalities of the lumbar roots in their extrathecal intraspinal course affect the clinical picture associated with disc lesions. These abnormalities are discussed in later sections of this book

[11] Falconer M A., McGeorge M., & Begg, A. C (1948) Observations on the cause and mechanism of symptom-production in sciatica and low back pain *J Neurol., Neurosurg Psychiat.*, 11 13-26

CHAPTER III

THE FUNCTION OF THE LUMBAR INTERVERTEBRAL DISCS

THE intervertebral discs are an integral part of the spinal column. Not only do they contribute to the length and shape of the spine but they are essential factors both in movement of the trunk and in transmission of weight. Because of the demands of function the structure of the discs is necessarily complex and each of their three component parts, the cartilage end plates, the annulus fibrosus and the nucleus pulposus, serve essential purposes. From the physiological point of view the intervertebral discs cannot be regarded as a simple single unit The role of its separate parts must be considered in order to gain a clear picture of its function as a whole.

Functions of the Nucleus Pulposus.

The nucleus pulposus is probably the most highly specialised part of the intervertebral disc. Formerly it was regarded as expansile and was said to exhibit turgor this view being held because nuclear tissue appeared to expand when exposed by cutting away the annulus or vertebral bodies. It was then believed to act as a shock absorber by virtue of its elasticity and it was considered that impacts were absorbed by expansion and contraction of the individual nuclei This view however is not correct.

Although the nucleus is plastic rather than fluid it obeys the laws of fluid and is therefore incompressible Moreover any force to which it is subjected is, as is the case with all fluids, transmitted equally in all directions. While the nucleus as a whole is incompressible it can alter its shape freely under the influence of pressure and its normal shape is determined by the elastic retaining annulus. These properties are essential factors in nuclear function

1 SHOCK ABSORBING MECHANISM —The fact that the nucleus is incompressible but can alter its shape makes it an essential part of the shock absorbing mechanism of the intervertebral disc. When the nucleus is subjected to pressure it flattens out slightly further distending the annulus (Fig 14). The compressing force is transmitted equally to all parts of the annulus, the elastic fibres of which become slightly more elongated. It is these annular fibres and not the nucleus which absorb and damp down the mechanical forces to which the spine may be subjected

2 EQUALISATION OF STRESSES —The equal transmission of force in all directions is an extremely important phenomenon Stresses are transmitted to and spread evenly over the entire annulus and over the whole of the cartilaginous end plates on the vertebral bodies irrespective of the relationship of these bodies to each other The annular fibres therefore share equally in the receipt of stresses

and the danger of one small area receiving the whole force and being overstretched or torn is obviated. As far as the vertebral bodies are concerned pressure is distributed evenly and consistently over the whole of the cartilage end plate. Were this not the case localised pressure over a small area might be associated with pressure absorption of the bony vertebral body.

3. Fluid Exchange between Vertebrae and Discs.—Fluid exchange between the discs and the adjacent vertebrae will be discussed more fully later. The nucleus plays an important part in this exchange, its substance acting as an impermeable solute which draws fluid by osmotic pressure from the vascular channels in the vertebrae.

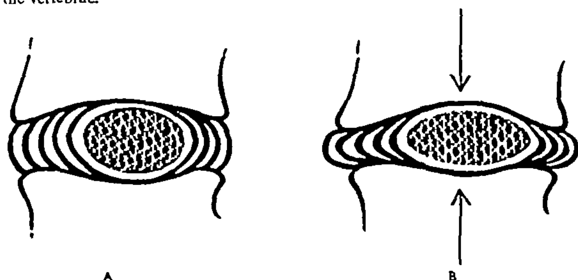


Fig. 14

Shock absorbing mechanism

The nucleus pulposus is incompressible but can alter its shape freely. Normally it is enclosed in the elastic annulus which it distends slightly (A). Under the influence of pressures the nucleus flattens a little, further stretching the annular fibres (B) which partly absorb the compressing forces.

4. Movement between adjacent Vertebrae.—It is of course obvious that the vertebrae move in relation to each other. The exact nature of this movement is much more complex than it might appear and this question will be considered in detail later. It has always appeared to the author however that some incompressible fulcrum between the vertebrae was essential to provide an axis for movement. The nucleus would appear to be the only structure mechanically suitable for this purpose.

Functions of the Annulus Fibrosus.

The annulus fibrosus is a fibro-elastic ring which surrounds the nucleus pulposus and forms the larger and peripheral part of the intervertebral disc. The fibres of the annulus are arranged in layers which are closely packed anteriorly and posteriorly and more widely spaced laterally. These layers gain attachment from the cartilage end plates and from the peripheral ring of bone surrounding these plates. The deeper layers are attached to the more central part of the plate so that the

annulus partly invests the nucleus above and below as well as peripherally The annulus has five main functions.

1 STABILITY —The annulus binds the vertebral bodies together so that the spinal column moves and functions as a whole. The strength of the annulus and the security of its attachment to the epiphyseal rings and end plates are very considerable. Tremendous force is required to tear or detach the annulus sufficiently to allow dislocation between adjacent vertebrae.

2. MOVEMENT BETWEEN VERTEBRAE.—The annulus permits a small range of movement between the individual vertebrae. This movement is possible partly because the annulus is slightly elastic and partly because of the arrangement of its fibres These pass in an oblique and spiral manner from one vertebral body to the next the fibres of successive layers lying at right angles to each other Slight movement of the vertebrae one on the other can take place in association with a change in the direction of these fibres.[1, 2]

3 CHECK LIGAMENT —The annulus acts as a check ligament Movement is limited by the fibres of individual lamellae becoming taut as the extremes of tilting or rotation between the vertebral bodies are reached

4 NUCLEAR RETENTION —The annulus acts as a retaining or containing envelope for the nucleus pulposus The nucleus is held in position and shape by the slightly elastic annulus The bulk of the normal nucleus is sufficient to distend the annulus slightly causing it to bulge outwards and stretching its fibres a little.

5 SHOCK ABSORBING MECHANISM —Finally and most important the annulus is, *as it were the spring in the spinal shock absorber* As has been pointed out the nucleus under the influence of pressure becomes slightly flattened and transmits the compressing force equally to all parts of the annulus. Under the influence of this force the elastic annular fibres, normally elongated a little by the nucleus, are stretched further (Fig 14). In this way all forces to which the spine is subjected are partially expended on and absorbed by the elastic annulus fibrosus of each intervertebral disc.

Functions of the Cartilaginous End Plates.

The cartilage end plates cover the central part of the upper and lower surfaces of the vertebral bodies being surrounded anteriorly and laterally by the epiphyseal ring and extending posteriorly almost to the vertebral rim The cartilage plates probably have two functions.

1 PROTECTION OF VERTEBRAL BODIES.—*It seems likely that the cartilage plates are partly protective in nature and that they shield the vertebral bodies from the effects of habitual transmission of weight* Watson Jones has pointed out that the

[1] Rouviere H (19 1) Sur le texture des disques intervertebraux. *C.R Soc Biol* 85 1 6 15
[2] Smith N H (1930/31) The intervertebral discs *Brit J Surg* 18, 358 375
Watson Jones R (1945) Robert Jones Memorial Lecture Royal College of Surgeons

ends of all bones which are constantly exposed to pressure are protected by a layer of avascular cartilage or fibrous tissue He has suggested that one of the most important functions of this avascular layer is to protect the bone itself from pressure atrophy The upper and lower surfaces of the vertebral bodies are of course, subjected to powerful compression forces of constantly varying intensity Pressure absorption does not occur however so long as the end plates remain intact

2. Fluid Exchange between Discs and Vertebral Bodies—The cartilage end plates act as a semi permeable membrane through which water is diffused to the avascular disc under the influence of osmotic pressure.

THE WATER EXCHANGE IN INTERVERTEBRAL DISCS

The intervertebral discs have a very high water content which is maximal at birth and decreases with advancing age Püschel[4] has estimated that in a normal disc the water content of the nucleus at birth is 88 per cent. This drops to 80 per cent. at the age of 18 and continues to decrease steadily until death the average content at the age of 77 being about 69 per cent At birth the annulus has a water content of 78 per cent and this decreases until in the third decade the content is about 70 per cent. This remains more or less unchanged until extreme old age when it again tends to drop a little The variations in water content with age are not therefore precisely similar in nucleus and annulus, since that of the nucleus undergoes a steady decrease throughout life while that of the annulus, after an initial decrease, remains fairly constant until extreme old age. The difference in water content between nucleus and annulus therefore tends to decrease steadily throughout life.

Since the adult discs are completely avascular their nutrition and the disposal of waste products are effected by diffusion There is in fact a very free water exchange between the discs and the adjacent vascular vertebral bodies and the mechanism whereby this exchange takes place is of some importance.

The passage of water from the vertebral body to the disc is produced by osmotic pressure. The cartilage end plate acts as a semipermeable membrane and the substance of the nucleus as an impermeable solute which draws water from the vascular vertebral bodies. The flow of water from vertebrae to disc is opposed by all the forces which tend to approximate the vertebral bodies and therefore compress the disc. These forces produce a positive hydrostatic pressure within the disc and should this exceed the osmotic pressure water is squeezed out from the disc into the vertebrae.

The intervertebral disc is under positive pressure at all times, the forces combining to produce this pressure being gravity muscle tone, muscle action and exertion. The pressure is less during sleep when the discs are relieved of much of the body weight and the muscles are relaxed It seems probable that during sleep the osmotic pressure always exceeds the disc compression and that the discs therefore absorb water During the day when the discs are subjected to pressures

[4] Püschel J (1930) Der Wassergehalt normaler und degenerierter Zwischenwirbelscheiben. *Beitr path Anat.*, 84 123-130

annulus partly invests the nucleus above and below as well as peripherally. The annulus has five main functions.

1. STABILITY.—The annulus binds the vertebral bodies together so that the spinal column moves and functions as a whole. The strength of the annulus and the security of its attachment to the epiphyseal rings and end plates are very considerable. Tremendous force is required to tear or detach the annulus sufficiently to allow dislocation between adjacent vertebrae.

2. MOVEMENT BETWEEN VERTEBRAE.—The annulus permits a small range of movement between the individual vertebrae. This movement is possible partly because the annulus is slightly elastic and partly because of the arrangement of its fibres. These pass in an oblique and spiral manner from one vertebral body to the next, the fibres of successive layers lying at right angles to each other. Slight movement of the vertebrae one on the other can take place in association with a change in the direction of these fibres.[1, 2]

3. CHECK LIGAMENT.—The annulus acts as a check ligament. Movement is limited by the fibres of individual lamellae becoming taut as the extremes of tilting or rotation between the vertebral bodies are reached.

4. NUCLEAR RETENTION.—The annulus acts as a retaining or containing envelope for the nucleus pulposus. The nucleus is held in position and shape by the slightly elastic annulus. The bulk of the normal nucleus is sufficient to distend the annulus slightly, causing it to bulge outwards and stretching its fibres a little.

5. SHOCK ABSORBING MECHANISM.—Finally and most important, the annulus is, as it were, the spring in the spinal shock absorber. As has been pointed out the nucleus under the influence of pressure becomes slightly flattened and transmits the compressing force equally to all parts of the annulus. Under the influence of this force the elastic annular fibres, normally elongated a little by the nucleus, are stretched further (Fig. 14). In this way all forces to which the spine is subjected are partially expended on and absorbed by the elastic annulus fibrosus of each intervertebral disc.

Functions of the Cartilaginous End Plates.

The cartilage end plates cover the central part of the upper and lower surfaces of the vertebral bodies, being surrounded anteriorly and laterally by the epiphyseal ring and extending posteriorly almost to the vertebral rim. The cartilage plates probably have two functions.

1. PROTECTION OF VERTEBRAL BODIES.—It seems likely that the cartilage plates are partly protective in nature and that they shield the vertebral bodies from the effects of habitual transmission of weight. Watson Jones[3] has pointed out that the

[1] Rouvière, H. (1921). Sur le texture des disques intervertebraux. *C.R. Soc. Biol.* 85, 156-157.
[2] Smith, N. H. (1930/31). The intervertebral discs. *Brit. J. Surg.* 18, 358-375.
[3] Watson Jones, R. (1948). Robert Jones Memorial Lecture. Royal College of Surgeons.

ends of all bones which are constantly exposed to pressure are protected by a layer of avascular cartilage or fibrous tissue He has suggested that one of the most important functions of this avascular layer is to protect the bone itself from pressure atrophy The upper and lower surfaces of the vertebral bodies are of course subjected to powerful compression forces of constantly varying intensity Pressure absorption does not occur however so long as the end plates remain intact.

2. Fluid Exchange between Discs and Vertebral Bodies—The cartilage end plates act as a semi permeable membrane through which water is diffused to the avascular disc under the influence of osmotic pressure.

THE WATER EXCHANGE IN INTERVERTEBRAL DISCS

The intervertebral discs have a very high water content which is maximal at birth and decreases with advancing age Püschel[4] has estimated that in a normal disc the water content of the nucleus at birth is 88 per cent This drops to 80 per cent. at the age of 18 and continues to decrease steadily until death the average content at the age of 77 being about 69 per cent At birth the annulus has a water content of 78 per cent. and this decreases until in the third decade the content is about 70 per cent. This remains more or less unchanged until extreme old age when it again tends to drop a little. The variations in water content with age are not therefore precisely similar in nucleus and annulus, since that of the nucleus undergoes a steady decrease throughout life while that of the annulus after an initial decrease, remains fairly constant until extreme old age. The difference in water content between nucleus and annulus therefore tends to decrease steadily throughout life.

Since the adult discs are completely avascular their nutrition and the disposal of waste products are effected by diffusion There is in fact a very free water exchange between the discs and the adjacent vascular vertebral bodies and the mechanism whereby this exchange takes place is of some importance.

The passage of water from the vertebral body to the disc is produced by osmotic pressure. The cartilage end plate acts as a semipermeable membrane and the substance of the nucleus as an impermeable solute which draws water from the vascular vertebral bodies. The flow of water from vertebrae to disc is opposed by all the forces which tend to approximate the vertebral bodies and therefore compress the disc. These forces produce a positive hydrostatic pressure within the disc and should this exceed the osmotic pressure water is squeezed out from the disc into the vertebrae.

The intervertebral disc is under positive pressure at all times the forces combining to produce this pressure being gravity muscle tone, muscle action and exertion The pressure is less during sleep when the discs are relieved of much of the body weight and the muscles are relaxed It seems probable that during sleep the osmotic pressure always exceeds the disc compression and that the discs therefore absorb water During the day when the discs are subjected to pressures

[4] Püschel J (1930) Der Wassergehalt normaler und degenerierter Zwischenwirbelscheiben. *Beitr path Anat.*, **84**, 123-130

which may rise to very great heights, exceeding the osmotic pressure within the disc, the passage of water is reversed and the discs actually shrink a little (Fig. 15).

Such a phenomenon would account for the diurnal variation in height which takes place in every individual. This has been studied by De Pukys[3] who observed that a decrease in height of approximately three-quarters of an inch in males and half an inch in females occurs during the day

This normal water exchange is profoundly affected by any variation in the cartilage end plate. With increasing age these plates become less permeable and the diurnal water exchange decreases This is probably associated with the decrease which takes place in the nuclear water content

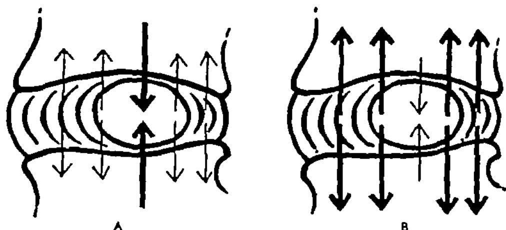


FIG. 15

Fluid exchange between vertebrae and disc

Fluid passes from the vertebrae to the disc under the influence of osmotic pressure, the cartilage end-plates acting as semipermeable membranes and the nucleus as an impermeable solute, and from the disc to the vertebrae under the influence of hydrostatic pressure produced by disc compression. During sleep the compressing forces are at a minimum, osmotic pressure exceeds hydrostatic pressure and fluid passes into the disc (A). During activity compression forces are maximal hydrostatic pressure exceeds osmotic pressure and fluid passes into the vertebral bodies (B)

The normal water exchange is quite profoundly affected by rupture of the annulus and associated escape of nuclear content. In these circumstances the function of the nucleus as an impermeable solute is lost and the disc remains become desiccated and fibrotic.

Charnley[4] has investigated the fluid absorbing properties of the lumbar discs and has shown that as the result of abnormal fluid imbibation pressure within the disc can rise considerably He has suggested that such an abnormal pressure increase may be a factor in the pathology of lumbar disc lesions.

MOVEMENTS OF THE LUMBAR SPINE

In the spinal column the attributes of stability and flexibility are combined in a most effective manner and for such a strong and massive structure the range of

[3] De Pukys, P (1935) The physiological oscillation of the length of the body *Acta orthopaed scand* 6, 338 347

[4] Charnley John (1951) Fluid imbibation as a cause of herniation of the nucleus pulposus. *J Bone Jt Surg.*, 33-B 472.

movement normally present is surprisingly large. The various regions are not equally mobile, however nor is movement in all the different planes uniformly distributed over the whole length of the spine. The lumbar and cervical are normally the most mobile parts and this is reflected in the relative thickness of the intervertebral discs in these regions Not only are the movements which take place in the lumbar region of clinical importance but the effects of these movements on the structures lying close to the spine and particularly on the contents of the spinal canal are of great significance.

Movements of the Lumbar Spine as a Whole

With the exception of the cervical the lumbar is the most mobile region in the spine As has been pointed out about one third of its length is made up by the five lumbar discs and the whole region constitutes about one third of the total length of the pre sacral column

Movements are produced by two large groups of muscles those attached to and acting directly on the spine and those attached to other parts of the skeleton and affecting the spine indirectly Of the direct action group the erector spinae the quadratus lumborum and the psoas are the most important while the abdominal muscles are the most powerful of the indirect action group.

The nature of the action of these muscles has been investigated by Floyd and Silver[7] who studied the action currents in the erectores spinae muscles during movement. With the spine in the erect or neutral position the muscles show minimal activity but they contract strongly as soon as movement begins. When the extremes of movement are reached muscle activity again ceases and while this position is maintained muscle action is again minimal. Contraction recurs with resumption of movement and continues as the spine returns to the neutral or upright position. These findings would indicate that when the spine is upright or neutral the body weight is transmitted entirely through the bony vertebrae and the intervertebral discs all muscles being relaxed At the extremes of movement the weight falls partly on the check ligaments the muscles again being relaxed while during movement the contracting muscles partly sustain the weight. The muscles themselves have a double function in that they initiate and control movement and also resist the forces of gravity in any position other than the upright or the extremes of movement.

In the neutral or upright position the lumbar spine is in a position of slight lordosis being convex anteriorly The degree of lordosis varies from individual to individual and is greater in the female than the male Normally the most anterior part of the lumbar convexity is the surface of the third and fourth vertebral bodies and in the erect position the vertical axis of the spine passes through the dorso-lumbar and lumbo-sacral junctions

Forward flexion takes place freely in the lumbar region and its range is greater here than anywhere else in the spine (Gray[8]) None the less the range of lumbar

[7] Floyd, W F., & Silver F H S (1951) Function of erectores spinae in flexion of the trunk. *Lancet* cclx, 133-134

[8] Gray Henry (1926) *Anatomy Descriptive and Applied* 23rd ed., 367 London Longmans, Green & Co



PLATE 1A

Radiograph taken in the standing position with the spine in full flexion. Although spinal flexion is greatest in the lumbar region it is relatively small in relation to the total amount of forward bending normally possible. Calculated in relation to the sacrum the range of vertebral tilting shown by Plates 1A and 1B is Sacrum/L.5 21 L.5/L.4 18 and L.4/L.3 15

1A



PLATE 1B

Radiograph taken in the standing position with the spine in full extension. Although spinal flexion is greatest in the lumbar region it is relatively small in relation to the total amount of forward bending normally possible Calculated in relation to the sacrum the range of vertebral tilting shown by Plates 1A and 1B is Sacrum/L.5 21 L.5/L.4 18 and L.4/L.3 15

flexion as shown by radiographs taken at the extremes of movement (Plates 1A and 1B) is surprisingly small in relation to the total forward bending of which the normal young adult is capable. Charnley[9] has pointed out that in the fully flexed position the lumbar spine at most merely becomes straight by obliteration of the normal lordosis and suggests that lumbar flexion only accounts for 20 per cent. of the total forward bending normally possible. More recently Allbrook[10] has investigated the range of movement using lateral radiographs of the lumbar spine taken in full extension, the erect position and full flexion By superimposing the sacrum in the different views drawing a line through the centre of the vertebral bodies parallel to their upper and lower surfaces and measuring the angle at the point of intersection of these lines in flexion and extension the total range of movement, in terms of tilting of the lumbar vertebrae in relation to the sacrum may be calculated. Although measurements using tracings of radiographs can only be approximately accurate they do afford one method of measuring lumbar movement. In Allbrook's[10] series of 14 men (12 African, two English) of an average age of 25 the mean tilt of the first lumbar vertebra in relation to the sacrum was 63·6 degrees between full flexion and full extension In a series of six females (four African two English) of an average age of 20 the range was 70·3 degrees It was also observed that movement was greatest in the lower lumbar region and decreased from below upwards These observations can easily be confirmed for example measured thus the range of vertebral tilting shown in Plates 1A and 1B is Sacrum L.5 – 21 L.5 L.4 – 18 and L.4/L.3 – 15

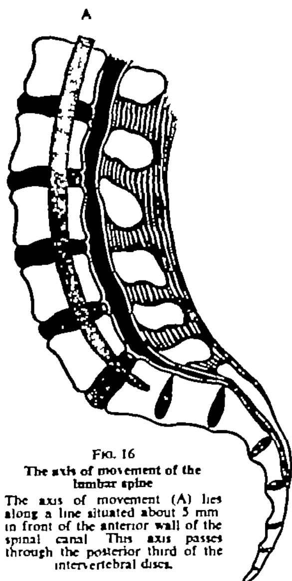


FIG. 16
The axis of movement of the lumbar spine
The axis of movement (A) lies along a line situated about 5 mm in front of the anterior wall of the spinal canal This axis passes through the posterior third of the intervertebral discs.

The total range of extension in a normal spine is much less than that of flexion. Normally limited by the anterior common ligament and by approximation of the

Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion. *Lancet* cclx, 186-192

Allbrook, D (1957) Movements of the lumbar spinal column *J Bone Jt Surg.*, 39B-2, 339-345

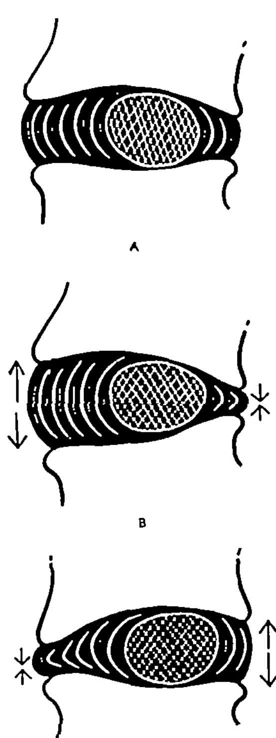


FIG. 17

Movement between individual vertebrae

When compared with the neutral position (A) the intervertebral spaces open up anteriorly and shut down posteriorly on extension (B) and reverse this movement on flexion (C).

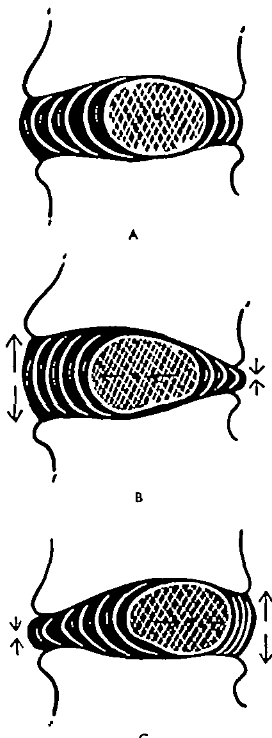


FIG. 18

Axis of movement between individual vertebrae

In the neutral position (A) the axis of movement lies within the nucleus. On extension the nucleus and axis of movement shift a little forward (B) while the reverse movement takes place in flexion (C)

spinous processes extension is greatest in the cervical region least in the dorsal region and relatively free in the lumbar region

Lateral flexion takes place freely in the lumbar spine but rotation is absent, being prevented by the planes of the posterior articular facets which lie across the plane of rotation

The axis of *movement of the lumbar spine as a whole has been investigated* in an ingenious manner by Charnley [11] Experiments with a hemi section of a fresh lumbar spine showed that the axis lies on a line passing somewhere through the posterior quarter of each intervertebral disc, this line being about 5 mm. in front of the anterior surface of the spinal theca (Fig. 16).

It is quite possible that movement of the lumbar spine may not take place with a synchronous uniformity over its whole length. It may be that flexion and extension take place by serial movements between individual vertebrae rather than by simultaneous movement between all the vertebrae concerned When adequate cine radiography of the spine becomes possible an exact knowledge of spinal movement may modify some of the present beliefs concerning its nature

Movements between Individual Lumbar Vertebrae.

Radiographs taken at the extremes of movement show how small a range actually occurs between individual vertebrae. At the extremes of extension the intervertebral spaces tend to open up a little anteriorly and to close down posteriorly while the reverse is true at the extremes of flexion (Fig. 17). The amount of movement between individual vertebrae is slight. Charnley[12] has calculated that the total depth of the anterior surfaces of the lumbar vertebrae and discs only increases by 12 mm on passing from full flexion to full extension. This increase occurs of course at the anterior surfaces of the discs and represents an average opening up of 2 4 mm. at each disc. The total depth of the posterior surface of the vertebral bodies and discs decreases by 5 mm. during the same movement, representing an average shutting down of 1 mm. at each disc.

The axis of movement between individual vertebrae is obviously a most important point. The site of this axis has never been conclusively demonstrated. Indeed it has been suggested that this axis is not fixed but changes during movement (Wiles[13]).

It would appear that some incompressible fulcrum must exist on which movement between individual vertebrae can take place. The only structure other than the posterior articular processes which is suitably incompressible is the nucleus pulposus and since normally the axis lies between the vertebral bodies it seems probable that *movement* takes *place* around the nucleus, which acts as a fulcrum. In the lumbar region the nuclei lie rather posteriorly in the intervertebral spaces so that they are traversed by the common axis of movement as calculated by

[11] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion *Lancet* eclx. 186-192.
[12] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion. *Lancet* eclx. 186-192
[13] Wiles P (1935) *Proc R Soc Med.*, 28, 647

Charnley Because of the fluid nature of the nucleus it seems quite probable that in fact the axis of movement is not completely fixed On extension of the spine the nucleus alters its shape somewhat so that the axis tends to shift forward and on flexion the nuclear shape alters so that the axis shifts slightly posteriorly (Fig. 18) To this extent therefore the axis of movement may be mobile rather than fixed It has also been suggested by Burns and Ellis[14] that in certain derangements of the intervertebral discs when the nucleus is destroyed the whole axis of movement is transferred posteriorly to the articular facets

The Effects of Spinal Movement on Adjacent Structures.

Movement of the lumbar spine involves all structures which lie close to the spinal column these becoming taut or relaxed as extremes of movement are approached The ligaments and the muscles actually check or control the degree of mobility but the other structures are only affected indirectly These facts are most important in relation to disorders of the lumbar intervertebral discs particularly as they affect structures lying within the spinal canal and must be considered in detail. The structures concerned are the spinal cord and cauda equina the spinal theca and the nerve roots in their extrathecal course

1 The Spinal Cord and Cauda Equina.—The spinal cord and the nerves of the cauda equina move freely in relation to the bony canal during flexion and extension of the spine and the relative movements become cumulatively greater the greater the distance from the foramen magnum The roots of the cauda equina in their intrathecal course are extremely lax and relatively elastic so that even at the extremes of flexion these roots do not become unduly taut.

2. Spinal Theca.—The dura mater is a strong fibrous inelastic membrane. Charnley[15] has pointed out that in the lumbar region the posterior dura is lax and redundant so that the 11 mm of lengthening which takes place at the posterior wall of the spinal canal on full flexion of the spine is compensated by a local taking up of the lax dura without this membrane being stretched beyond its maximum length

Anteriorly the dura is much tauter and is closely applied to the posterior surface of the vertebral bodies and discs without the intervention of any areolar tissue. The anterior dura is held in position by the roots in their extrathecal course each of which carries with it a sheath of inelastic dura on leaving the theca and each of which is fixed distally by branches given off on leaving the intervertebral foramen Since the anterior wall of the canal lies much closer to the axis of movement than the posterior its excursion of movement is much less. On passing from full extension to full flexion the length of this wall is only increased by 5 mm and this movement is probably distributed evenly over the theca and five extrathecal roots each of which has only to absorb a normal range of movement of 1 mm Both roots and dura can normally accommodate themselves to

[14] Burns, B H & Ellis, V H (1937) *Recent Advances in Orthopaedic Surgery* 181 London, Churchill

[15] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion *Lancet* cclx, 186-192.

this comparatively small range of movement without being stretched beyond their normal tolerance.

The Effects of Straight Leg Raising.

One of the most important clinical tests in the diagnosis of lumbar disc lesions is observation of the effects of raising the extended leg. A full consideration of the possible anatomical effects of this test will be found in a later section but its effects on the lower lumbar roots are so akin to those produced by flexion of the lumbar spine and by forward bending that *they may well be considered here.*

When the straight leg is raised tension on the fourth and fifth lumbar and first sacral roots on the same side is increased and as a result these roots move *into the foramina* The range of root movement has been observed in the cadaver and has been variously estimated as between 2 5 mm (Inman and Saunders[16]) 2 6 mm (Falconer McGeorge and Begg[17]) and 4 8 mm. (Charnley[18]). Charnley has further pointed out that root movement does not occur uniformly through the 90 degrees of straight leg raising which are normally possible. The root remains stationary *until the leg has reached an angle of between 30 degrees and 40 degrees* above the horizontal after which it starts to move suddenly and goes on moving until 70 degrees is reached Beyond this point movement is slow and by the time the leg has reached 90 degrees the root has been stationary for some time.

It should be noted that the range of movement of the lower lumbar roots produced by raising the straight leg is much greater than that produced by flexion of the lumbar spine alone. Forward bending from the erect position on the other hand corresponds to bilateral straight leg raising in the supine position and in fact *more of this movement takes place at the hips than by flexion of the spinal column*

The effects of straight leg raising on the roots of the opposite side have been observed in the cadaver by Woodhall and Hayes.[19] When the straight leg is raised *the roots on the contralateral side emerge a little from their foramina and shift* slightly towards the opposite side, at the same time tending to approach the anterior wall of the spinal canal. The first sacral and fifth lumbar roots are more affected than the fourth lumbar root by this contralateral movement (Fig. 38 A & B).

THE FORCES ACTING ON THE LUMBAR INTERVERTEBRAL DISCS

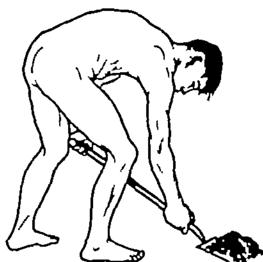
During life the intervertebral discs are constantly subjected to pressure by forces which tend to drive together the vertebral bodies. These forces differ in the various regions of the spine and are affected by posture movement and activity

Gravity is one factor which affects the lumbar discs. In the erect position the weight of the trunk arms and head is transmitted through the lumbar spine

[16] Inman, V T., & Saunders, J B de C (194) *Radiology* 38, 609
[17] Falconer M A., McGeorge M., & Begg, A C (1948) *J Neurol Neurosurg Psychiat.*, 11 13
[18] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion. *Lancet* cclx, 186-192.
[19] Woodhall, B & Hayes, G J (1950) The well leg raising test of Fajersztajn in the diagnosis of ruptured lumbar intervertebral disc *J Bone Jt Surg.*, 32-A, 786-79_

producing constant pressure on the lumbar discs The effects of gravity are reduced by sitting with the arms supported and disappear almost completely on lying down

Muscle tone also produces constant pressure on the intervertebral discs In the lumbar region tone in the erector spinae and abdominal muscles constantly tends to approximate the vertebrae compressing the discs This pressure never disappears completely even during sleep



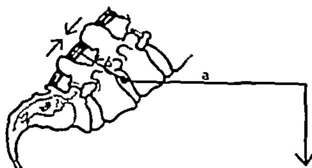


Fig. 19
The forces acting on a lumbar intervertebral disc

If considered in terms of a single lumbar disc, on lifting a heavy weight (A) the arms and trunk form a long anterior lever (a) The force of the weight acting along this lever must be balanced posteriorly by the spinal muscles acting over a much shorter lever (b). If the relationship between these levers is 15 1 lifting 100 lbs. in this way imposes a total force of 1,600 lbs. (three-quarters of a ton) on the disc

The widest variations in the pressure to which the discs are subjected are, however produced during activity Contractions of muscles occurring in association with movement increase pressure and such actions as lifting a weight or pushing against resistance further increase this force. Bradford and Spurling[14] have pointed out that these forces are greatly increased by the lever mechanism which comes into play when the arms are used. If the nucleus pulposus of a lower lumbar disc is considered as the fulcrum of movement and a heavy object is lifted with the hands the arms and trunk form a long anterior lever The weight lifted is balanced by contraction of the erectores spinae acting posteriorly over a very much shorter lever The ratio between the anterior and posterior levers is computed as about 15 1 and if a weight of 100 lb were lifted this would only be balanced by muscle contraction to a force of 1,500 lb posteriorly the discs therefore being subjected to a total pressure of 1 600 lb or almost three-quarters of a ton (Fig. 19).

[14] Bradford, F K., & Spurling, R. G (1945) *The Intervertebral Disc* 2nd ed., 28 Illinois, Thomas.

Apart from its purely mechanical effects, activity is associated with a general increase in muscle tone and under the strains of violent exertion the forces to which the discs are subjected are said by Petter[21] to rise to incredible heights.

Various experiments have been carried out in cadaveric spines in an attempt to compute the normal or average pressure to which discs are subjected during life. All such experiments are, however open to grave objections on theoretical grounds and it seems certain that in fact, this pressure alters constantly and widely When lying down pressure is minimal being produced only by muscle tone in the upright position pressure increases, being produced by the weight of the upper part of the body and the forces of muscle tone. Any alteration in position adds the force of muscle contraction to pressure and activity in any form causes further steep rises in the compressing forces.

[21] Petter C. K. (1933) Method of measuring the pressure of the intervertebral disc. *J Bone Jt Surg.*, 15, 365-368

CHAPTER IV

THE PATHOLOGY OF LUMBAR DISC LESIONS

INJURY or degenerative changes may affect the intervertebral discs in any part of the vertebral column and disease of the vertebral bodies may also involve adjacent discs either directly or indirectly The discs may be affected singly in one particular region or universally throughout the whole spine, and many of the clinical syndromes associated with disorders thus produced are characteristic

We are concerned however with one particular pathological process that which produces the so-called lumbar disc lesion This term unsatisfactory though it may be in some respects, has come to be accepted as meaning one definite pathological cycle associated with a characteristic clinical syndrome In the past much misconception about the true nature of the pathology of lumbar disc lesions has been caused by the nomenclature applied to this condition The terms slipped or displaced disc are in common usage even by the medical profession and are not only meaningless but actively misleading. The terms retropulsed prolapsed or herniated disc are little better being only a partially accurate description of one phase of a disease process. A much more accurate if less elegant appellation would be a burst disc

The essential pathological feature of lumbar disc lesions is that they are not associated with one single change or abnormal condition but with a cycle of changes. Broadly speaking, these lesions begin with degenerative changes involving the nucleus pulposus and posterior annulus Later annular rupture may occur to be followed by backward displacement of fragmented nuclear material Finally the disorganised disc heals by a process of fibrosis this process being associated with disorganisation of and degenerative changes in the affected intervertebral joints.

AETIOLOGY

The aetiology of this particular condition is uncertain One fact alone appears to be indisputable—the discs commonly affected are those of the lower lumbar and lower cervical regions It is probably significant that these are the sites of the secondary curves of the spinal column These secondary curves, produced by an increase in the anterior depths of the discs are developed to meet the demands of the erect posture It is possible that degeneration of the nuclei of the intervertebral discs belongs to that considerable group of lesions, semi mechanical in origin which constitute one of the penalties paid by man for the assumption of the upright position

It is also true that the discs most commonly affected are those which are relatively thickest and that this increased thickness is associated with an increased mobility between contiguous vertebrae The cervical and lumbar regions are the most mobile parts of the spine, and the cervical and lumbar discs might reasonably be supposed to be subjected to more wear and tear than those elsewhere

The following may be aetiological factors leading to the development of lumbar disc lesions.

1 **Trauma.**

In the past all lumbar disc lesions *were considered to be traumatic in origin.* Although it quickly became obvious that many typical lesions were not preceded by injuries of any kind the belief in trauma as a major aetiological factor dies hard, *and indeed some evidence may be adduced to support this hypothesis.*

About 60 per cent. of patients give a history of injury before the onset of their symptoms. Indeed the association is often dramatic—a flexion strain, a *feeling of something* "snapping" in the low back and the sudden onset of crippling symptoms. Moreover, apart from the question of any single specific injury there is quite commonly a history of some unusual and unaccustomed heavy exertion. A change of occupation, a house moving or perhaps a week's intensive gardening may precede the onset of symptoms.

On the other hand, several facts seem to indicate that trauma is not necessarily an important factor in the production of nuclear degeneration.

About 40 per cent. of patients give no history of injury and are quite emphatic that their symptoms have developed spontaneously. Indeed, some surgeons have reported a much higher percentage of patients giving no history of trauma, for example, Eyre Brook[1] records a personal series of 117 patients of whom only 16 were injured, the injury being trivial in five instances.

Even in those patients with the clearest history of a single injury and a sudden onset of disability it is most unusual to find a complete absence of premonitory *symptoms. Almost invariably such patients have had some low back* pain either mild or severe, before the injury to which they attribute their symptoms.

Moreover, consideration of the relatively common fractures of the vertebral *bodies suggests first that the normal intervertebral disc is not easily damaged* and second that the lower lumbar region is not an area of the spine particularly exposed to injury. Fractures of the vertebral bodies occur most commonly in the upper *lumbar and lower dorsal regions, and it is unusual to find that damage to the inter*vertebral disc, as indicated by a distortion or diminution of the intervertebral space is produced even by forces which are sufficient to crush and compress the bony vertebral body.

Finally, in a high proportion of patients associating their symptoms with trauma the precipitating injury is of an extremely trivial nature and in many cases the action producing symptoms is one which *the patient has habitually performed* for many years without obvious ill-effects. It seems highly unlikely that such exertions as lifting a suitcase, twisting into an unusual position, or perhaps coughing or sneezing with the spine in flexion could damage a normal disc, *a structure which* resists forces sufficient to crush a vertebral body.

[1] *Eyre Brook, A. L. (1952) A study of late results from disc operations. Brit. J. Surg.* xxxix, 89-296.

It may be that in some instances a severe injury produces a rupture of a normal annulus fibrosus posteriorly where both the annulus and its attachments are weakest and that failing such an injury this rupture would not have occurred It may also be that a single injury can be followed by degenerative nuclear changes which produce symptoms at a much later date In very many cases, however the evidence suggests that injury is a precipitating rather than a causal factor Some trivial violence which would not affect a normal disc may rupture a diseased annulus but such a rupture is inevitable and is bound to occur sooner or later

2. Developmental Abnormality

It has been suggested that developmental defects may play some part in the process leading to retropulsion of the lower lumbar nuclei Different authors have attached a varying significance to this possibility the consensus of opinion appearing to be that such anomalies may account for disc lesions in a small proportion of cases. Harvey Jackson [2] however has stated that in his view all disc protrusions most likely are of developmental nature possibly increased by other levers in the forms of trauma toxaemia and pregnancy

It has been pointed out that such abnormalities are common in the lumbo-sacral region and are particularly associated with the caudal end of the notochord Since the nucleus pulposus is partly developed from notochordal tissue abnormalities of the nuclei might be expected Irregularities in the shape of the lower lumbar nuclei have in fact been described Hyndman [3] has reported irregular or hour-glass nuclei and associates these abnormalities with certain types of disc lesions.

It is difficult, however to believe that nuclear abnormalities account for all or even a material proportion of such lesions Irregularities in the shape of the nucleus pulposus are not commonly met with on post mortem examination of the spinal column nor are they observed at operative exploration of the lower lumbar discs.

There is, however another possibility regarding the relationship between congenital anomalies and degenerative lesions of the lower lumbar discs Weakness of the bony and ligamentous structures produced by some abnormality may cause abnormal stresses to fall on the lower lumbar discs. As a result of these increased stresses, degenerative changes may occur in these discs Perhaps the most obvious example of how such a defect might affect the stability of the low back is a spina bifida oculta of the first sacral vertebra an anomaly very commonly seen in association with a disc lesion. A spina bifida of the first sacral segment may be associated with weakness or deficiency of the interspinous and supraspinous ligaments and loss of the restricting effect of these ligaments on flexion With the loss of this buffer the forces of flexion fall on the lower lumbar discs and may be

[2] Jackson, Harvey (1947) *The association between certain anatomical facts normal and morbid and the symptomatology of intervertebral disc protrusions in the lumbar region* Hunterian Lecture delivered at the Royal College of Surgeons of England on 10th July
[3] Hyndman, Alan R (1946) Pathologic intervertebral disc and its consequences. *Arch Surg.*, 53, 247

a causal factor in subsequent degenerative changes. Similar although less obvious, mechanical effects may be produced by the other common congenital abnormalities.

3 Compression Stress.

Lindblom[4] has investigated the effects of compression stress on the intervertebral discs Rats tails were fixed in flexion thus producing a compression stress on one side of the discs, and subsequently degenerative changes and annular ruptures were found in the compressed areas. Lindblom[5] has suggested that such stresses may produce disc lesions in man and that such factors as the wearing of high heels may account for the higher incidence of disc lesions in modern as opposed to prehistoric man If however postural compression was an important factor in the production of lumbar disc lesions one would expect a higher than normal incidence in patients with a lordosis and in women as opposed to men There is in fact no such increase and the sex distribution is about equal.

4 Imbibation of Fluid.

It has been shown by Charnley[6] that one of the properties of the disc is the power to imbibe fluid and that as a result of fluid absorption pressure within the disc rises. He has suggested that such a pressure rise might be a factor in the production of nuclear displacement It should be remembered however that the compression forces to which the lumbar discs are normally subjected are tremendous far exceeding any rise in their internal pressure. In the presence of an annular rupture these compressing forces tend to produce nuclear extrusion.

5 Mental Stress.

It has often been suggested that there is always some psychological overlay in the complaints of patients suffering from low back pain or sciatica The implication has been that this caused these patients, consciously or unconsciously to magnify their symptoms and disability Scott[7] has investigated the possibility of mental stress directly affecting the discs. He points out that in recent years there appears to have been a general increase in the incidence of low back pain on the one hand and of psychosomatic disorders on the other and that these two conditions might be interconnected He also points out that in voles subjected to mental stress (daily periods of fighting) typical changes occur in the thymus adrenals and spleen. Scott investigated the discs in voles subjected to mental stress and found a significant increase in the area of nucleus pulposus in relation to the total disc area, these changes being proportional to the changes in the thymus, adrenals and spleen While too much should not be read into this experiment the possibility

Lindblom, Kurt (1952) Experimental rupture of intervertebral discs in rats tails. *J Bone Jt Surg* 34-A 123-128.
Lindblom, Kurt (1957) Intervertebral disc degeneration considered as a pressure atrophy *J Bone Jt Surg* 39 A 933-945
Charnley John (1951) Fluid imbibation as a cause of herniation of the nucleus pulposus. *J Bone Jt Surg* 33-B, 472.
Scott J C (1955) Stress factors in the disc syndrome. *J Bone Jt Surg*, 37 B, 107 111

that mental stress may by disturbing the water balance of the body possibly through endocrine factors cause an increase in fluid absorption and consequently a rise in the internal pressure of the lumbar discs cannot be dismissed

6 Degeneration

The operative findings in a large series of patients suggests that retropulsion of the nucleus of a lower lumbar disc occurs as the result of a process of degeneration

There can be no doubt that the pathological changes are progressive and that the lesion passes through a series of stages, no one of which can be regarded as constituting the typical disc lesion The cycle is distinct and definite and the appearance of the disc and nucleus suggests that these changes are degenerative in nature.

It is true that to attribute the process to degeneration is to some extent begging the question of its basic aetiology It is not however possible in the present state of our knowledge to determine the cause of such degeneration or to say why some discs degenerate and others do not Probably as in degenerative arthritis many factors are involved Wear and tear trauma focal sepsis pregnancy nutrition and perhaps the most important, the inherent quality of the fibrous and elastic tissue in the individual concerned may each play its part.

7 Some Other Causes So Far Unknown.

It is, of course, possible that the pathological process leading to retropulsion of the nucleus is due to some cause at present unsuspected or unknown.

While it is fairly easy to compile a list of possible causes as the author has done, we do not at present know why lumbar disc lesions occur This being so investigations into their aetiology will obviously continue in the hope that, if the cause were known, it would be possible either to prevent these lesions or to treat them more effectively Although such investigations are obviously highly desirable the author considers it unlikely that disc lesions are in fact due to any single cause. It would seem to him that, while they may be initiated or hastened by such things as injury abnormal sustained mechanical stress, disorders of the body fluid balance mental stress, pregnancy or even focal sepsis it is probable that several of these factors are concerned in each lesion It is also probable that in most people the lumbar discs are at some time or other subjected to some or all of these factors, and that whether or not degenerative changes take place depends in the last resort on the inborn quality of the disc tissue

GENERAL CONSIDERATIONS

Far less is known of the exact pathology of lumbar disc lesions than of the symptoms they produce or of their surgical management. These lesions are never fatal and the mortality associated with operative treatment is, or should be negligible With advancing age the composition of the disc changes and the end stages of old lesions bear little relation to their earlier phases For these reasons

we are dependent on the observations of the surgeon rather than on the pathologist for our knowledge of disc pathology

It should not be assumed that the surgeon has failed to make the most of his opportunities The lower lumbar discs are surgically inaccessible and at best only a small portion of the posterior aspect of the annulus can be exposed to direct vision Even then the disc lies at the bottom of a deep wound and is partly obscured by structures which must be handled with care. For a knowledge of the interior of the disc the surgeon is dependent on his sense of touch and on examination of such disc substance as he may remove. It is not surprising that complete and accurate observations are difficult under these circumstances.

Considerable experience is necessary to differentiate between the normal and some types of abnormal discs, and to appreciate the various degrees of pathological change Many discs must be explored before personal observations become of real value and then, since the disc changes are progressive, it is necessary to explore many more in order to observe every phase in the pathological cycle Observations *based on a small series of patients are necessarily incomplete and of limited value* and since the findings recorded depend mainly on the highly individual sense of touch a completely accurate picture cannot be produced by compiling the published records of several fairly small series of patients

It might seem that these views over-emphasise the difficulties of complete and accurate observation of the pathological changes associated with degeneration of the lumbar disc nuclei It should be remembered, however that nuclear protrusions were seen and recorded for years before it was even recognised that they were associated with the intervertebral discs.

The pathology of disc lesions can be considered from two aspects. The local and progressive changes in the disc itself are of course, of primary importance. These changes may be correlated with the surgical findings and the clinical manifestations. Equally important, however particularly from the clinical point of view are the secondary effects of the local changes. Adjacent structures are involved either directly or indirectly and these secondary changes are responsible for many of the characteristic symptoms and signs associated with the condition

THE LOCAL DISC CHANGES

The anatomy of the healthy lumbar intervertebral disc has already been described and it has been pointed out that since the disc changes with advancing age there is no single normal. In the young adult the nucleus is firm springy and elastic, blending with and merging *into the surrounding annulus fibrosus.* With advancing age the nucleus loses part of its water content and becomes less elastic and less differentiated from the annulus

Degenerative lesions of the lower lumbar discs pass through three stages. It is impossible to over-emphasise the importance of the recognition of the existence and nature of these stages. Unless they are clearly understood there can be no logical approach either to diagnosis or treatment

First Stage

The first stage may be defined as those changes which take place prior to the displacement of nuclear material

The earliest observed change is a softening of the nucleus and of the posterior part of the annulus The nucleus is affected first and commences to disintegrate and break up the end stage of this process being complete fragmentation the nucleus then consisting of a varying number of separate and unattached solid fragments which lie free and surrounded by a quantity of homogeneous semi fluid material At the same time the posterior part of the annulus is affected and its fibres become softer and break up an area of varying size being affected

Although there may be some general weakening of its posterior part complete disintegration of the annulus usually takes place over a comparatively small area to one or other side and at a varying distance from the middle line. The first stage may be considered to end with rupture or perforation at this point and the contents of the disc are then only retained in position by the overlying posterior longitudinal ligament

The final annular rupture may occur gradually as a result of a slow process of disintegration or it may be precipitated by some trauma which tears the weakened fibres. When the annulus gives way the nuclear changes may be more or less complete but quite often the nucleus has not at this time broken up completely or separated into entirely detached fragments

Second Stage

The process of posterior displacement of part or all of the nucleus constitutes the second stage of the pathological changes

The duration of this stage may vary greatly and it is a mistake to regard retropulsion of the nucleus as necessarily being a sudden catastrophe occurring as a result of injury and consequent rupture of the annulus. In many cases extrusion is a gradual and intermittent process in its entirety and in the remainder only part of the nuclear displacement occurs suddenly

The nucleus is under positive pressure at all times and slightly distends the elastic annulus which retains it in position When the annulus gives way either because a small area of its entire thickness has disintegrated or because injury has ruptured a degenerate or even a healthy portion of its posterior part, the nucleus tends to bulge through the defect, being only partly retained in position by the posterior longitudinal ligament A normal nucleus is to some extent anchored in position by the fibrous tissue framework which binds it to the annulus and only local bulging takes place if the annulus gives way or is incised over a comparatively healthy nucleus (Fig 20) The tendency to herniate through the annular gap is greatly increased if the nucleus is degenerated and fragmented. Soft broken up nuclear tissue and the semi-fluid material surrounding it are readily extruded and quite large fragments may be squeezed out completely

Once the annulus has given way the posterior longitudinal ligament is not strong enough to prevent the nucleus herniating. It has been suggested that this

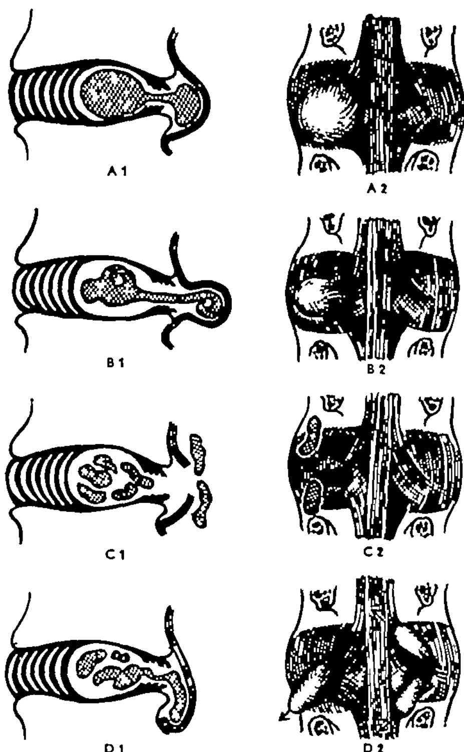


FIG. 24
The various types of nuclear protrusions
A (1) and (2)—Bulge or protuberance.
B (1) and (2)—Sessile or pedunculated.
C (1) and (2)—The free sequestrum.
D (1) and (2)—The dissecting protrusion.

(Fig. 24A) Occasionally the protrusion may be more sessile or even definitely pedunculated (Fig. 24B)

The pedunculated protrusion which is usually produced by the complete extrusion of a sequestrated fragment may burst through the ligament so that the nuclear sequestra pass freely into the spinal canal (Fig 24C) When the posterior longitudinal ligament ruptures and nuclear sequestra escape into the spinal canal these fragments form loose bodies or canal mice which may move some distance from their point of origin Such fragments commonly follow the course of the extrathecal root and may become impacted in the spinal foramen causing root pressure at this point.

More commonly however the sessile nuclear sequestrum becomes folded over and flattened down by the posterior ligament and may then extend a considerable distance in any direction from the site of its exit from the disc. This type the

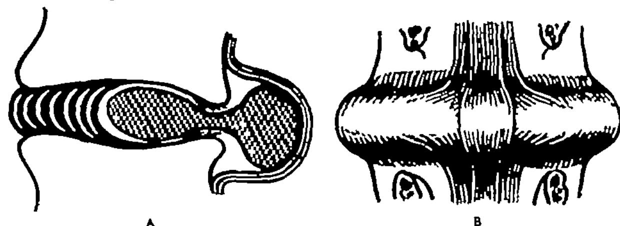


FIG. 25
The massive protrusion
In this type of protrusion which usually occurs in the puerperium, the whole of the posterior annulus gives way and the nucleus is displaced backwards in its entirety

so-called dissecting protrusion strips the posterior ligament from its attachment and spreads away from its point of exit under cover of the ligament. These dissecting protrusions may spread either upward or downward and medially in the line of the ligamentous fibres but often extend laterally along the line of the nerve root towards or even into the intervertebral foramen (Fig. 24D).

Certain other variations of the more usual types of protrusions occur occasionally The whole of the posterior part of the annulus may give way so that the nucleus bulges backwards along its whole length. This seems to occur most commonly in the puerperium when the degenerative process seems to affect the already-softened fibrous tissue more widely and more profoundly than usual. This type of massive protrusion may be very large and in these cases the nucleus seems to be posteriorly displaced in its entirety (Fig. 25)

Another variation is the bilateral protrusion A protrusion which originally occurs in the usual site may with increasing and spreading weakness of the annulus extend across the middle line (Fig. 26A) or may be complicated by the appearance of a second and distinct protrusion on the opposite side (Fig. 25B).

The posterior protrusion does not necessarily consist entirely of nuclear tissue. The annular changes may extend beyond the area which actually gives way and annular fringes may project into the spinal canal around the nuclear tissue (Fig. 27A). Occasionally quite large segments of annulus may become detached and may swing backwards into the canal as a hinged annular flap (Burns and Young[4]) (Fig. 27B).

The second stage may continue for varying periods. Nuclear extrusion once established usually continues intermittently for months if not for years. If part of the nucleus has been completely extruded it is impossible that this portion can be replaced within the annulus. The positive pressure within the intervertebral

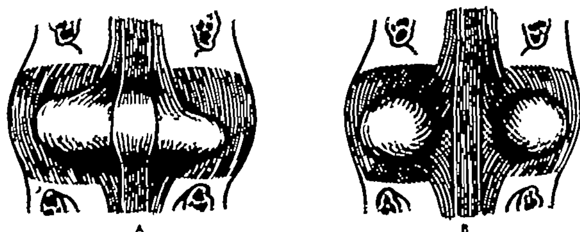


Fig. 26

The bilateral protrusion

A unilateral protrusion may with spreading weakness of the annulus, extend across the middle line (A) or may be complicated by the appearance of a second separate protrusion on the opposite side (B).

space is too great to permit of reduction of the herniated fragment either by direct pressure or by any manipulation of the lumbar spine. It is true that an extrusion in the earlier bulging stages can be made much more obvious by any thing which increases intervertebral pressure. This pressure is probably at a minimum in a deeply anaesthetised patient whose lumbar spine is in the neutral position and it can be increased by any generalised muscle contraction such as is produced by coughing or straining, or by extreme flexion or extension of the lumbar spine The increase and decrease in the bulge produced by these means is however in no way a true reduction of the displaced tissue. Much misconception exists on this point and this is probably partly due to the common use of such terms as herniated displaced or slipped disc.

Third Stage.

Part of the nucleus having been extruded further changes take place both in the displaced material and in the remainder of the intervertebral disc. This con

[4] Burns, B H., & Young, R. H (1945) Protrusion of intervertebral disc. *Lancet* ccxlix, 4 4-477

stitutes the third and final stage of the disc lesion and is in some respects a process of repair

These changes commence with the rupture of the annulus and the extrusion of nuclear tissue and progress slowly for months and even years Since several nuclear extrusions may occur at intervals this third stage in its earlier phases overlaps the second to some extent

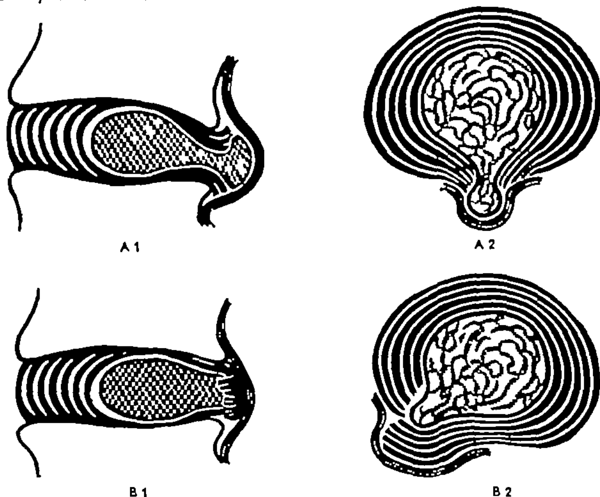


FIG. 27

Annular components in nuclear protrusions

Annular fringes may project into the spinal canal around the nuclear tissue (A (1) A (2)) or a hinged flap of annulus may be swung backwards (B (1) B (2)).

Freshly extruded nuclear material is springy and elastic, being very similar in texture to the normal nucleus pulposus Completely sequestrated fragments are usually irregular flattish pieces which are tightly rolled on themselves when they are removed. Once extruded the nuclear tissue begins to lose its elasticity and becomes fibrous and increasingly hard. At the same time its bulk decreases and the whole protrusion shrinks a little this decrease in size being due in part to loss of water content and in part to fibrosis It has been pointed out by Lindblom and Hultqvest[1] that this extruded tissue is also actually invaded and eaten away

[1] Lindblom, K., & Hultqvest, G (1950) Absorption of protruded disc tissue. *J Bone Jt Surg* 32-A, 557 561

by granulation tissue. These authorities believe that this process of absorption is one of the more important factors in the healing of these lesions.

The final change is calcification of the displaced nuclear tissue. Calcified deposits appear and spread in the protrusion itself until ultimately the whole may be converted into a hard bony nodule At the same time new bone formation may occur at the points where the posterior longitudinal ligament has been stripped from the vertebral body and the spurs thus formed often spread into the displaced tissue (Fig. 28) This process is very similar to the lipping which occurs in degenerative arthritis but is localised to the region of the protrusion. In its final appearance an old lesion is a hard calcified nodule, considerably smaller than a recent disc protrusion, and is fixed in position This nodule often adheres closely to the adjacent structures, notably to the nerve root, and this very important feature will be fully discussed when the secondary effects of the disc lesions are considered.



FIG. 28

Final calcification of a nuclear protrusion

New bone formation occurs at the points where the posterior longitudinal ligament has been stripped from the vertebral body (a, a) and calcified deposits appear and spread in the protrusion itself (b)

Following rupture of the annulus and partial retropulsion of the nucleus pulposus, very marked changes take place in the undisplaced portion of the disc. A completely degenerated nucleus is fragmented and consists of unattached masses of nuclear tissue lying free in amorphous semi fluid material. This breaking up may not be complete when the annulus ruptures and nuclear tissue is then less freely and less completely extruded than is the case in what Hyndman[10] graphically describes as the ripe disc. Degeneration of the nucleus may continue after the annulus has ruptured and as the nuclear tissue degenerates more fragments tend to be extruded, together with the semi fluid matrix in which they lie

Apart from this continued nuclear breakdown and possible further retropulsion the disc tissue which remains in its normal position alters in nature once the annulus has been ruptured. There is no sudden marked diminution of the intervertebral space with the escape of nuclear tissue. Even after complete operative removal of the nucleus gross alteration in the intervertebral space is not radiologically apparent for some months (Gillespie[11]). The nucleus comprises less than one-quarter of the total volume of the lower lumbar discs and even if half the nucleus was extruded suddenly the intervertebral space would only thereby be

[10] Hyndman, Alan R. (1946) Pathologic intervertebral disc and its consequences. *Arch. Surg.*, 53, 247

[11] Gillespie H W (1947) Further observations on radiological diagnosis of lumbar intervertebral disc lesions. *Brit J Radiol* 20 70

diminished by one-eighth Once nuclear retropulsion has occurred the rest of the disc is affected both by fibrosis and by dehydration These processes particularly



PLATE 2A
The last stage of a disc lesion, an established degenerative arthritis of the joint between the vertebral bodies, with narrowing sclerosis and lipping.

the latter cause shrinking and loss of elasticity of the damaged disc. The inter vertebral space becomes progressively narrowed and the intervertebral joint is deranged

Abnormal pressure also produces changes in the adjacent vertebral bodies. A layer of sclerotic bone appears deep to the cartilage end plates and there is some

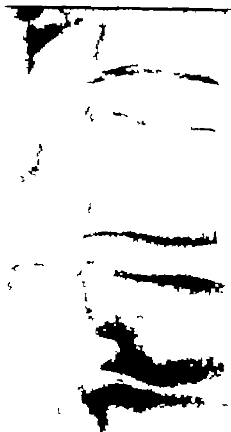


PLATE 2B

The last stage of a disc lesion, an established degenerative arthritis of the joint between the vertebral bodies, with narrowing sclerosis and lipping.

new bone formation around the periphery of the contiguous surfaces. Ultimately the disc remains become dense fibrous tissue and the intervertebral space is diminished to between half and quarter of normal (Plate 2).

This narrowing of the space between the vertebral bodies affects the posterior diarthrodial articulations Alteration in the plane of the articular surfaces of these joints is followed sooner or later by arthritic changes Ultimately the changes typically associated with degenerative arthritis—narrowing of the joint spaces subchondral sclerosis peripheral new bone formation and periarticular fibrosis—may be observed in these joints

The final stages of a disc lesion consist therefore of a progressive degenerative arthritis of the affected intervertebral joint both the anterior and the posterior parts of the joint being affected In favourable circumstances a firm fibrous ankylosis of the arthritic joint may form and this represents the end stage of natural healing of a lumbar disc lesion

CHAPTER V

THE PATHOLOGY OF LUMBAR DISC LESIONS

(Continued)

SECONDARY CHANGES ASSOCIATED WITH DISC LESIONS

THE complete pathological picture of lesions of the lower lumbar discs includes both local changes in the disc itself and secondary changes in other structures, produced directly or indirectly by disorganisation of the normal disc anatomy and function From the clinical point of view such secondary changes are at least as important as the primary changes within the disc.

CHANGES IN THE STRUCTURES OCCUPYING THE SPINAL CANAL

One group of secondary effects are the direct result of posterior displacement of nuclear material. The tumour thus produced projects backwards, coming into contact with and affecting in various degrees the structures occupying the spinal canal In this respect the size and site of the protuberance is of great significance as is the size and shape of the canal itself

1 Effects on the Intrathecal Roots of the Cauda Equina.

In those occasional cases in which the whole of the posterior part of the annulus gives way and the nucleus is extruded completely the size of the protrusion is sufficient seriously to occlude the spinal canal. In these circumstances the spinal theca is compressed and both the extrathecal and intrathecal roots of the cauda equina are pressed on at the level of the protrusion (Fig. 29). If the protrusion is very large and the bony canal is small pressure produced in this way may be sufficient to cause a partial or complete paralysis of all the affected nerves. This type of sudden cauda equina paralysis is associated with a characteristic clinical picture.

2 Effects on the Cerebrospinal Fluid.

A massive retropulsion compressing the theca and intrathecal roots produces complete blocking of the flow of cerebrospinal fluid at the level of the compression. This is followed by the usual loculation syndrome with changes in the colour and protein content of the cerebrospinal fluid below the level of the block While a complete block is only produced by the rare massive retropulsion it seems probable that other large protrusions may be associated with partial or intermittent obstruction of the cerebrospinal fluid flow with consequent less marked changes in its protein content.

3 Effects on the Spinal Theca

The most usual type of retropulsion is not associated with general and severe pressure effects A unilateral protrusion is in contact with the spinal theca and one

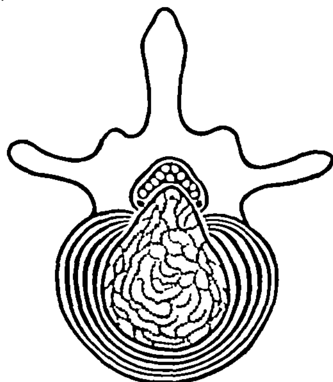


FIG. 29
Pressure effects from massive protrusion
A massive posterior displacement of nuclear tissue may occupy most of the spinal canal causing actual compression of the spinal theca and both the intra and extrathecal roots at this level

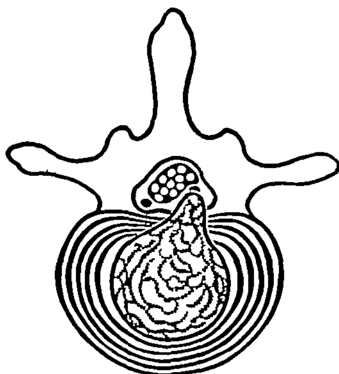
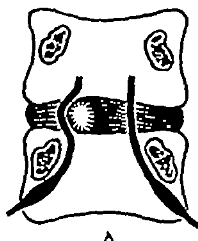
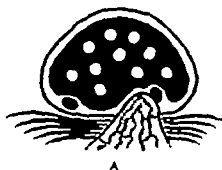
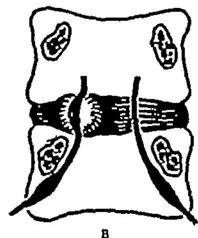


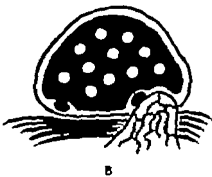
FIG. 30
Pressure effects from usual type of protrusion
The ordinary protrusion does not materially occlude the spinal canal but is in contact with and raises the tension in one root in its extrathecal intraspinal course

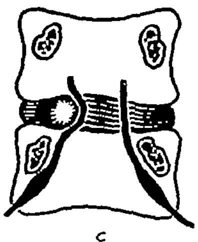
or more roots in their extrathecal course Its effects on the intrathecal structures are slight or absent since its bulk is not sufficient to produce severe pressure (Fig. 30). Such a protrusion does not tend to adhere to the theca to any extent











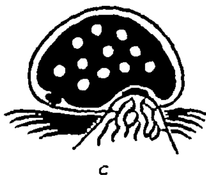


FIG. 31

Root-protrusion relationships

The site of the protrusion varies in its relationship to the root in its extrathecal course. The tumour may be on the inner side (para caudal) (A), on the outer side (pararhyzal) (B) or directly below (subrhyzal) (C) the root.

FIG. 32

Root-protrusion relationships

The root may be displaced outwards (A) or inwards (B) or may be flattened over the summit of the protrusion (C)

but it is possibl that local irritation may occur at the point of contact with th theca and that such irritation may have reflex effects

4 Effects on Extrathecal Roots

A nuclear protrusion does produce very marked and important changes in th extrathecal roots with which it may come into contact

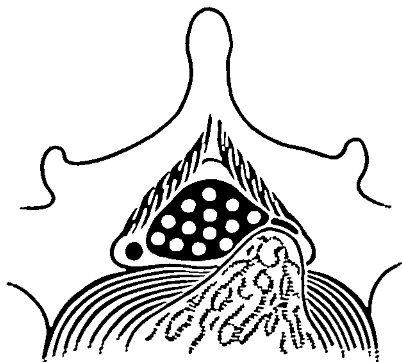


FIG 33

Root compression by a protrusion

If the protrusion is large and the spinal canal is small and slightly trefoil in shape the root may actually be compressed between the tumour and the bony wall of the canal, which is at this point covered by the lateral free edge of the ligamentum flavum.

The exact root protrusion relationship varies and it is customary t retropulsion as paracaudal or pararadicular depending on whether t inner or outer side of the root (Harvey Jackson[1]). This distincti artificial as the protrusion may in fact lie directly below as well as or other side of the root which crosses the affected disc oblique downwards (Fig. 31)

The roots are in direct and intimate contact with the disc a inelastic in their extrathecal course so that they are immediately protrusion The root tension is raised and the root itself may t or other side or to lie flattened over the most prominent part of th (Fig. 32). e nd ards

[1] Jackson, Harvey (1947) *The association between certain anatomic morbid, and the symptomatology of intervertebral disc protrusions* Hunterian Lecture delivered at the Royal College of Surgeons of e cl 315

Occasionally the root may actually be compressed between the protrusion and the bony wall of the spinal canal or lateral free edge of the ligamentum flavum.

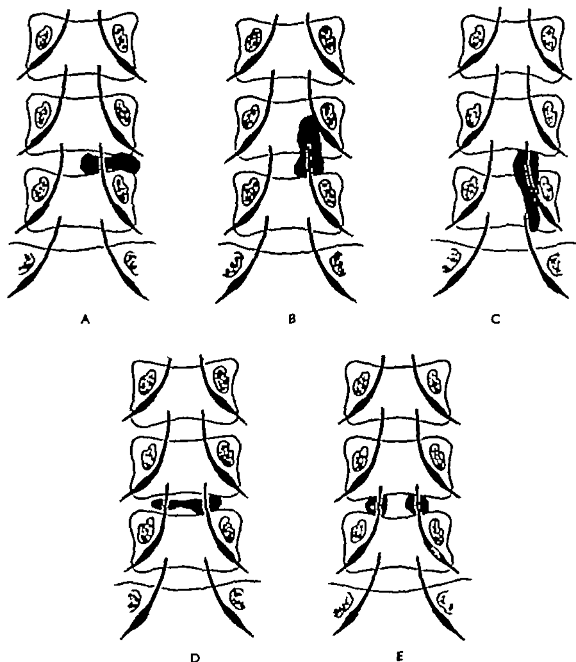


FIG. 34

Patterns of double root involvement

A sessile or dissecting protrusion may track lateralwards, involving a root in the foramen (A), or may track upwards or downwards involving the root above (B) or below (C). A bilateral protrusion may affect the roots on both sides (D) and these roots may similarly be involved in a double protrusion (E).

This is particularly liable to happen if the protrusion is large and the canal is small or slightly trefoil in shape (Fig. 33).

The root may therefore be either stretched or actually compressed as the result of nuclear displacement and it is possible that the effects of increased tension and of pressure are associated with different clinical syndromes (O Connell[1])

Another characteristic and important feature is the tendency for nerve roots to adhere to the protrusion Even in the earliest stages adhesions form binding the root down quite firmly In older lesions these adhesions become fibrous and massive and when the protrusion reaches the calcified stage the root may be so fixed that it appears to be partly buried in the bony nodule

As the result of local irritation certain changes occur in the root itself In the early stages it is oedematous and red and some petechial haemorrhage may appear in its sheath Later fibrosis may take place and some fasciculi may be affected by degenerative changes

Although a unilateral protrusion usually only involves the one root with which it is in direct contact such is not necessarily the case Two roots on one side or the roots on both sides at the same level may be affected These different patterns of root involvement are of the utmost importance since they explain variations in the clinical syndrome

Involvement of two roots on one side may occur in two different ways A dissecting or sessile protrusion may project directly laterally into the intervertebral foramen and cause pressure on the root leaving the canal at this level It should be noted however that the root lies in contact with bone as it traverses the foramen and is only affected at this point by a sequestrum which is sufficiently large to block the whole aperture (Fig. 34A) A large dissecting protrusion may extend upwards or downwards rather than laterally and may consequently involve the roots above or below either by direct pressure or by adhesion formation (Fig 34B & C).

The central type of protrusion may lie directly between the roots on each side and affect neither or if it is larger or more diffuse it may affect the roots on both sides simultaneously Since such protrusions are rarely truly central one root is usually more severely involved at an earlier stage than the other (Fig. 34D) The roots on both sides may also of course be affected by the bilateral type of protrusion when two retropulsions occur independently of each other (Fig. 34E).

CHANGES IN THE INTERVERTEBRAL JOINT

Disorganisation of the intervertebral joint is one of the more important of the secondary effects of a lumbar disc lesion Not only are the mechanics of the joint immediately disturbed but a cycle of progressive secondary changes is set in motion which ultimately alters the nature of the articulation profoundly

It seems probable that the normal axis of movement between contiguous vertebrae lies within the nucleus and that the nucleus acts as an incompressible fulcrum at which movement may take place With destruction of the nucleus and posterior displacement of the nuclear tissue the axis of movement shifts backwards and may be transferred to the posterior articulation (Burns and Ellis[2])

[1] O Connell J E. A. (1943) Sciatica and the mechanism of the Production of the clinical syndrome in protrusion of the lumbar intervertebral disc *Brit J Surg.*, **30** 120 315

[2] Burns, B H., & Ellis, V H (1937) *Recent Advances in Orthopaedic Surgery* 181 London, Churchill.

Normally the body weight and other compression forces are transmitted through the nucleus, the hydraulic action of which distributes pressure equally over the surface of the vertebra and the annulus fibrosus (Fig. 35A). With the disintegration and escape of nuclear tissue this hydraulic action is lost. On flexion of the spine heavy and localised pressure falls on the anterior parts of the vertebral end plates so that pressure absorption may produce bony changes in this area. The posterior articulations are also subjected to increased stresses because of the loss of the nuclear fulcrum (Fig. 35B)

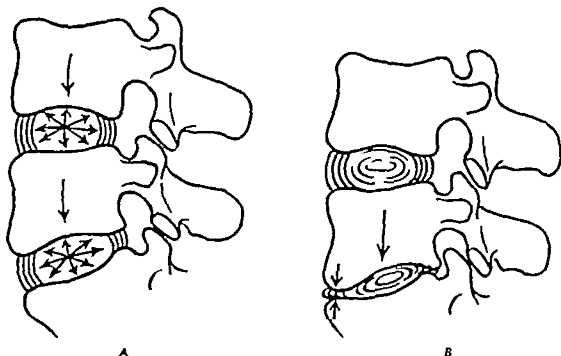


FIG. 35

Effects of nuclear destruction on intervertebral joint

Normally compression forces are transmitted through the nucleus and distributed evenly over the annulus and cartilage end-plates (A). With nuclear destruction pressure is no longer evenly distributed (B). Narrowing of the space between the vertebral bodies is associated with incongruity of the articular surfaces of the posterior joints.

With the loss of part of the disc tissue by nuclear retropulsion and shrinkage of the remainder by dehydration and fibrosis the space between the vertebral bodies becomes narrowed. This narrowing of the anterior part of the joint affects the posterior articulations the articular surfaces of which are no longer quite congruous so that these joints tend to open out a little (Fig. 34B). This disturbance of the normal joint mechanics ultimately produces a progressive degenerative arthritis of the posterior articulations.

Diminution of the intervertebral space also affects the posterior ligaments. Approximation of the vertebral bodies is associated with a posterior opening out of the spinous processes and a stretching of the supraspinous and interspinous ligaments and the ligamenta flava. As a result of these increased strains the ligaments may become hypertrophied and thickened.

The late changes which take place in the anterior part of the joint fibrosis and dehydration of the remaining disc tissue gradual narrowing of the intervertebral space the appearance of a layer of sclerotic bone on the surfaces of the vertebral bodies and finally the formation of osteophytic outgrowths around the periphery of these surfaces have been described already

Movement of an intervertebral joint is affected by the development of an inter vertebral disc lesion With the escape of part of the nucleus the annular fibres which bind the vertebrae together become slacker and allow an increased range of movement The immediate effect of nuclear retropulsion is therefore an increased mobility of the corresponding intervertebral joint Later as the intervertebral space decreases and the disc remains become fibrotic the vertebral bodies become bound together and the range of movement in relation to each other decreases With the subsequent development of arthritic changes a progressive diminution of movement continues and ultimately the joint may become ankylosed by fibrous tissue.

THE SITE OF LUMBAR DISC LESIONS

The discs most commonly affected are the fourth and fifth lumbar the third lumbar disc is occasionally but less frequently involved and lesions of the first and second lumbar discs have only been reported rarely The exact percentage of lesions occurring at these respective sites seems to be fairly constant.

Simultaneous lesions of two discs are not by any means unusual and estimates of the incidence of such double lesions vary between 10 and 20 per cent. of all cases. In the author s series both the fourth and fifth lumbar discs were inspected in all patients irrespective of whether or not there was clinical evidence suggesting a double lesion

In a series of 500 patients O Connell[4] reports the following findings —

L.5 S 1 disc lesions	49 6 per cent.
L.4 L.5 disc lesions	39 6 per cent
L.2 L.3 and L.3 L.4 disc lesions	1 6 per cent.
Double lesions	9 2 per cent

The author s figures in a series of 1,000 consecutive cases in which the findings were confirmed at operation were —

L.5 S 1 disc lesions	468 (46 8 per cent.)
L.4 L.5 disc lesions	404 (40 4 per cent.)
L.1 L.2 and L.3 disc lesions	21 (2 1 per cent.)
Double lesions	107 (10 7 per cent.)

THE PRODUCTION OF SYMPTOMS

A degenerate lesion of a lumbar intervertebral disc is associated with signs and symptoms which are in the main referred to the low back and to one or both

[4] O'Connell, J E. A. (1951) *Protrusion of the lumbar intervertebral discs. J Bone Jt Surg* 33-B, 8 30

legs. These are due partly to the primary changes in the disc itself and partly to involvement, either directly or indirectly of adjacent structures.

The mechanism whereby symptoms are produced is complex and is only in part understood

LOW BACK SYMPTOMS.

The clinical findings associated with a disc lesion and referred to the low back are pain muscle spasm abnormalities of posture and disturbance of spinal movement.

There are three root pathways concerned in the production of these phenomena (Table I).

TABLE I
NERVE PATHWAYS INVOLVED IN THE PRODUCTION OF SYMPTOMS

Abnormal Structure	*Nerve*	*Root*
Posterior annulus and posterior longitudinal ligament at level of disc lesion. Theca in contact with nuclear protrusion.	Nervus sinuvertebralis.	Roots leaving canal by foramina two and one segment above the level of the disc lesion.
Posterior articulations, ligamenta flava, supraspinous and interspinous ligaments.	Articular and ligamentous branches of the posterior primary divisions of root.	Root leaving canal by foramen at level of disc lesion.
Protrusion in direct contact with root in its extrathecal course	None	Root leaving *theca* at level of disc lesion and *canal* at foramen one below level of disc lesion

The posterior part of the annulus has a nerve supply (Roofe[3]) originating from the recurrent branches of the posterior primary divisions of the roots one and two segments above, the nervus sinuvertebralis of von Luschka [4]

The spinal theca in contact with the abnormal disc has a sensory nerve supply which is also derived from these recurrent branches of the posterior primary divisions of the lumbar roots.

The posterior intervertebral articulations and the posterior ligaments which may be secondarily affected by a disc lesion also have an ample nerve supply derived from the posterior primary divisions of the lumbar roots

The lumbar root which in its extrathecal course is in contact with and affected by the abnormal disc has a wide distribution to the skin and muscles of the lumbar region through its posterior primary division

Pain in the Low Back.

It seems probable that at least four different types of low back pain are associated with a lesion of one of the lower lumbar discs It is characteristic of

[3] Roofe P G (1939) Innervation of annulus fibrosus and posterior longitudinal ligament *Arch Path* 27 201 211
[4] Von Luschka, H (1858) *Die Halbgelenke des menschlichen Körpers* vol 4 Berlin, G Reimer

such lesions that the nature and severity of the pain produced varies not only from individual to individual but also from time to time in the same individual

1 One variety appears to be a typical ligamentous or deep pain Dull and aching in character it is poorly localised and constantly present but varies in intensity such variation being associated with changes in the exciting stimuli The patient always describes this discomfort or pain as being deeply seated or central It should be remembered that Lewis[1] believed that this deep pain is quite a distinct and separate form of sensation from cutaneous pain It seems probable that in the low back deep pain originates from the disc itself as a result of the degenerative changes which take place in the nuclear tissue The posterior inter spinous and supraspinous ligaments and ligamenta flava may when they are stretched by disorganisation of the anterior part of the intervertebral joint be a second potential source of deep or ligamentous pain

2 Direct irritation of a root in its extrathecal course by a posterior protrusion commonly produces pain referred to the cutaneous distribution of the affected root It is usual to pay particular attention to this referred pain in relation to the distribution of the anterior primary division of the root when pain is felt in the leg and constitutes sciatica There can be no doubt however that not uncom monly root irritation produces pain referred accurately to the cutaneous distribu tion of the posterior primary division of the affected root This is of course felt in the lumbar or posterior iliac region

3 The third type of pain is of quite a different character In its most severe forms it is of dramatic onset and of crippling intensity The patient is suddenly seized with an acute and agonising pain in the lumbar region so that any movement becomes intolerable This phase may last for a few moments or for a few days but gradual improvement which may be spontaneous but is hastened by rest, is usual. This type of pain may be less severe at its onset and in these circumstances the patient may be fairly comfortable so long as the lumbar spine is held immobile, although any movement produces sharp discomfort usually described as being of a stabbing nature Occasionally this acute type of pain may disappear as suddenly as it appeared

The mechanism whereby this so-called lumbago is produced has been a matter of some controversy In the opinion of the author this syndrome is due to an internal derangement of the disorganised intervertebral joint. This takes the form of a 'locking of the joint by a nuclear sequestrum which becomes impacted between the posterior rims of the vertebral bodies (Fig. 36A and B) Relief of symptoms is associated either with subsequent shrinkage of the sequestrum, when symptoms disappear slowly or with the unlocking of the joint due to the nuclear fragment being extruded posteriorly or else slipping back into the central concavity between the vertebral bodies (Fig. 36C and D). When the joint unlocks in this manner relief of low back symptoms may be dramatic.

4 In the late stages of a disc lesion when the affected intervertebral joint is undergoing arthritic changes it becomes a source of the type of pain characteristically

[1] Lewis, Thomas (1942) *Pain* New York, Macmillan & Co

associated with degenerative arthritis. Such pain is fairly well localised and is variable and affected by activity. Typically the patient states that the back becomes stiff or painful after remaining in one position for any length of time and improves when it is loosened or warmed up. Excess activity however causes a recurrence of symptoms which may persist for some time after the activity has ceased.

These four different types of discomfort or pain probably occur in all disc lesions at some stage and may co-exist. This accounts for the wide variation in the degree of pain so characteristic of the condition.

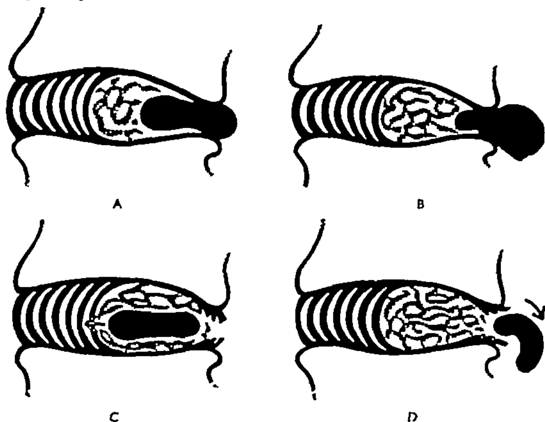


Fig. 36

Impacted nuclear sequestrum

A nuclear sequestrum may become impacted between the posterior rims of the vertebral body. The main bulk of such a sequestrum may be in the concavity between bodies (A) or in the spinal canal (B). With subsequent shrinkage the sequestrum may slip back between the vertebrae (C) or be extruded completely (D).

Muscle Spasm.

Some spasm of the erectores spinae muscles is a universal finding in all active lumbar disc lesions. This spasm is reflex and is designed to protect and immobilise the affected joint. The intensity of the spasm is a useful clinical guide to the activity and extent of the underlying lesion.

Abnormalities of Posture.

Lumbar disc lesions are commonly associated with alteration in posture in the form of flattening of the normal lumbar lordosis and, in some patients, a scoliosis. There are two possible causes of these phenomena. They may be due to an

abnormality or derangement of an intervertebral joint or they may be a reflex attempt to relax the root which is stretched by a posterior protrusion It seems

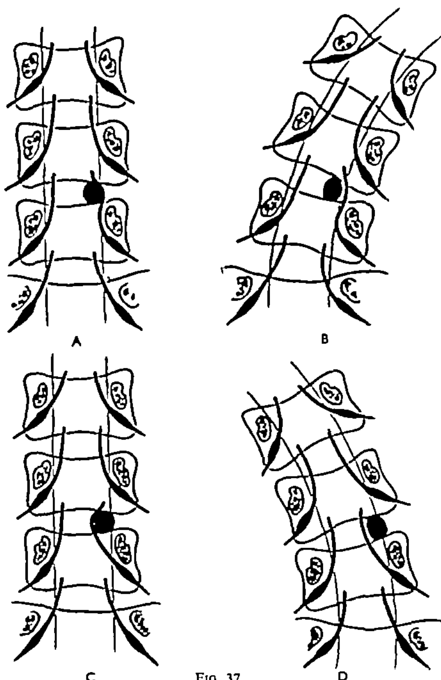


Fig. 37

Postural scoliosis in relation to root tension

With a paracaudal protrusion (A) root tension may be relieved by a lumbar scoliosis concave towards the side of the lesion (B) If the protrusion is pararhyzal (C) the scoliosis will relieve tension if it is convex towards the side of the lesion (D)

certain that flattening of the normal lordosis is due to joint derangement as it quite often occurs when there is no evidence of root irritation and in any circumstances this movement, as Charnley[4] has pointed out, does not greatly affect root tension

[4] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion. *Lancet* cclx, 186-192.

Postural scoliosis, on the other hand, while it may be due to joint derangement, is undoubtedly commonly associated with alterations in root tension. If the protrusion is pararadicular in site a lumbar scoliosis convex towards the lesion might reduce root tension, while the converse would be true of a paracaudal protrusion The less common alternating scoliosis is almost certainly associated with a root which slips over the summit of a protrusion (Fig 37)

Disorders of Movement.

An active lumbar disc lesion produces limitation of and pain on movement of the lumbar spine, forward flexion and extension being more affected than lateral flexion and rotation Three factors are probably associated in producing derangement of movement.

Disorganisation of the affected joint, particularly when this is associated with a sequestrum which may produce partial locking, obviously affects movement of this segment of the spine

Stretching of the torn or degenerated annulus and overlying portion of the *posterior longitudinal ligament is associated with any flexion of the spine and pain* thus produced causes reflex muscle spasm and inhibition of this movement.

Forward flexion and extension of the lumbar spine is probably associated with an alteration in the tension in and consequently in the size of some types of protrusion In these circumstances the patient tends to adopt the position of minimum tension and to avoid movements which would produce an increase in the size of the protrusion with a consequent stretching of associated structures.

SYMPTOMS REFERRED TO THE LEGS

Most lesions of the lower lumbar discs are associated at some time with symptoms or signs referred to one or both legs. These are pain sensory change, muscle weakness, muscle wasting and alteration in the knee and ankle jerks, and the mechanism whereby they are produced is relatively simple.

Pain.

Pain referred to one or both legs the classical sciatica is often from the patient's point of view the predominant feature of a disc lesion There are two varieties of such pain, which probably co-exist in most instances

1 Irritation of one of the lower lumbar roots in its extrathecal course is undoubtedly associated with pain referred to the cutaneous distribution of the affected root. Root irritation probably takes the form of an increase in the root tension as the result of *its being displaced by a posterior protrusion* and the relationship between root involvement and pain referred to the leg cannot be doubted Such pain is accentuated by anything which raises root tension and is dramatically relieved by operative removal of the associated protrusion It is also indisputable that pain is by far the commonest presenting symptom of root involvement and that it is rare to find sensory motor or reflex disturbance preceding or

referred to mesodermal elements connected with the skeleton and of the same embryonic level as the affected structures and Inman and Saunders[13] have suggested that it may be called sclerotogenous as opposed to dermatogenous. Sclerotogenous radiation probably occurs in disc lesions and would not be referred to the cutaneous distribution of any single root. Such pain is deep, aching and poorly localised and might, of course occur in the early degenerative stages of a lesion before any root involvement had taken place.

Sensory Changes.

Involvement of a nerve root is often accompanied by sensory changes in the skin area which it supplies These may take the form of abnormal sensation such as tingling or pins and needles or in blunting or loss of sensitivity Although it is probable that some sensory disturbance is usually associated with an increase in root tension it seems likely that in its most severe forms, and particularly when unaccompanied by pain it is produced by actual compression of the affected root.

Motor Changes.

Although slight muscle weakness and wasting usually occur in association with prolonged and severe root irritation by increased tension gross changes in the form of marked weakness or even paralysis of a muscle group accompanied by rapid and severe wasting only occur as a result of severe root compression Indeed, the presence of these changes is a most useful guide to the nature of the root involvement.

Reflex Changes.

When root function is disturbed there is associated diminution or complete loss of the reflex tendon jerks in which the affected root is concerned Alteration of these reflexes is an early and reliable sign of root involvement.

It should be noted that with the exception of deep referred pain all the clinical findings referred to the legs are associated with involvement of the roots of the cauda equina by contact either in their intra or extrathecal course with the intraspinal protrusion produced by posterior displacement of nuclear tissue The nature and severity of these findings vary with the size of the protrusion the size and shape of the spinal canal, and the exact root protrusion relationships.

REMISSION OF SYMPTOMS

One of the most characteristic features of lumbar disc lesions is the episodic nature of the symptoms they produce Not only is this a source of confusion both to patients and to their medical advisers but also the fact that advice is usually sought during an acute phase which is followed in the natural course of events by a remission accounts for the apparent success of many worthless therapeutic measures. Periodic remissions and exacerbations of symptoms are not always easy

[13] Inman, V T., & Saunders, J B de C M (1947) Anatomico-physiological aspects of injuries to the intervertebral disc J Bone Jt Surg 29 2.

to explain in that they do not necessarily appear to be associated with any obvious change in the underlying pathological condition It seems certain that a number of different factors may be concerned in variations in the clinical picture

1 The Sudden Commencement of Nuclear Extrusion.

Rupture of the posterior annulus and the sudden commencement of nuclear extrusion is always associated with a sharp exacerbation of symptoms It is when this happens that the patient feels something snap click or 'give way in the low back If at this stage a nuclear sequestrum becomes impacted between the posterior rims of the vertebral bodies the intervertebral joint locks and the patient is seized with agonising and incapacitating pain in the low back

2. Alteration in the Position of an Impacted Nuclear Sequestrum.

It seems to be widely believed that the posterior displacement of nuclear tissue is a reversible phenomenon in its entirety and that the disc can 'slip in and out. It is highly unlikely however that true reduction of completely extruded nuclear tissue can possibly take place. The forces which cause nuclear extrusion are very powerful and the positive pressure in the intervertebral space is such that it is difficult to imagine any force which might be brought to bear on displaced tissue so that it could be pushed back between the vertebral bodies

What can happen however is that a displaced or partly displaced sequestrum may alter its position A fragment which has become locked between the vertebral bodies may as a result of shrinkage or spinal movement (Fig. 36) slip back into the central concavity or be extruded entirely with consequent unlocking of the joint and a dramatic change in the patient's symptoms.

Further the nuclear tissue forming a posterior protrusion may alter its position either by bursting through the posterior ligament and escaping into the spinal canal or by shifting its position under a portion of ligament which has been lifted from its attachment. Alterations in the position of the protrusion may affect the nature of root involvement, with a consequent alteration in root symptoms.

3 Episodic Increases in Size of Protrusion.

Retropulsion of nuclear tissue is itself an intermittent phenomenon After an initial escape of degenerate tissue a state of temporary equilibrium is reached until movement or muscular effort, producing a rise in pressure between the vertebral bodies, causes further displacement. *Alterations in the amount of displaced* material, with consequent increases in the bulk of the protrusion may be associated with changes in the patient's symptoms.

4 Fresh Tearing of Posterior Annulus.

Flexion of the lumbar spine imposes a strain on the posterior part of the annulus fibrosus and may cause fresh tearing of the damaged or degenerate area. Such an extension of annular damage is associated with an exacerbation of the patient's symptoms.

5 **Local Oedema.**

Extrusion of nuclear tissue is associated with local swelling both in the region of the displaced material and of the involved nerve root. Variations in the degree of swelling may account for alterations in the patient's symptoms. Falconer and others[14] have carried out serial myelograms, and their findings suggest that root oedema can subside materially while the disc protrusion remains unaltered.

6 **Shrinkage of Nuclear Protrusion.**

There is no doubt that a nuclear protrusion fibroses and shrinks quite rapidly and the high water content of nuclear tissue makes it possible for such a protrusion to shrink to about one-quarter of its original size. This is, of course associated with an alteration in pressure symptoms.

7 **Adaptation of Roots to Pressure and Tension.**

It is probable that the roots in their extrathecal course may adapt themselves to an increase in tension or pressure produced by a nuclear protrusion. Such adaptation is associated with a decrease in the patient's symptoms particularly with a decrease in the fast type of pain and such an improvement would persist until a further increase in the size of the protrusion produced another rise in root tension

8 **Variations in Root Protrusion Relationship.**

A root may alter its relationship to a nuclear protrusion so that a decrease in root tension results. For example, a root may slip off the summit of a protuberance or move from one side of it to another because of a change in the patient's posture. Such alterations might be associated with changes in root symptoms.

9 **Root Lengthening.**

It has been suggested that roots under abnormal tension may actually lengthen Experiments by Dawbin and others[1] showed that when small blocks of wood or wax were placed under the lower lumbar roots in cats so that these were rendered taut actual lengthening of the roots occurred so that when re-examined two weeks later they were found to be slack.

10 **Nerve Adherence in Later Stages.**

A nerve root stretched by a nuclear protrusion quickly adheres to the protrusion As the nuclear tissue fibroses and shrinks the adhesions organise and the root becomes more and more firmly bound down to the abnormal disc. At this stage the adherent root is very liable to traction injury on movement, either active

[14] Falconer M A., McGeorge M., & Begg. A. C. (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J Neurol Neurosurg Psychol* 11 13 26.
[15] Dawbin, W., Cole D S., & Glasgow G L, quoted by Falconer M A., McGeorge M & Begg. A. C (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J Neurol Neurosurg Psychol* 11 13 26.

or passive, of the lumbar spine or affected leg and any such stretching is associated with a recurrence of symptoms.

11 **Permanent Changes in the Nerve Root**

As a result of long-continued pressure permanent degenerative changes may take place in an extrathecal root. With the complete loss of function of some sensory fibres pain sensation may disappear

With all these possible sources of irregular variation in the patient s symptoms it is not surprising that a lumbar disc lesion should be episodic in its clinical manifestations. It is probable that most if not all of these factors affect the course of each individual case in its various stages.

'NORMAL' OR SYMPTOMLESS DISC PROTRUSIONS

It is convenient at this stage to consider the evidence as to whether or not symptomless or normal posterior displacement of nuclear substance can occur The work of Andrae[16] is constantly quoted to support the contention that such displacements are fairly common and often unassociated with symptoms.

These symptomless protrusions were first observed by von Luschka,[17] re discovered by Schmorl[18] and further investigated by Andrae.[19] The last named reports that he found posterior nuclear displacements in 15 2 per cent. of 368 spines examined. These were mainly central in type, lying over the central band of the posterior longitudinal ligament, and were more common in females than in males (18 7 per cent. as opposed to 11 5 per cent.). Protrusions were mainly seen in the lower dorsal and upper lumbar regions and were most usual over the age of 50 never being observed under the age of 30 They were always associated with degenerative changes in the disc itself never projected more than 4 mm. into the spinal canal and were apparently unassociated with symptoms.

It seems clear that these lesions while possibly related to differ in site in age incidence in size and in their effects from degenerative changes as seen in the lower lumbar discs. It is certain that no evidence has as yet been advanced to show that degenerative lesions of the lower lumbar discs with associated posterior displace ment of nuclear material commonly occur without producing symptoms. In the opinion of the author these symptomless protrusions are one of those medical myths which arise from a misinterpretation or mistranslation of some original work and thereafter creep from paper to paper and text book to text book in seeming perpetuity

[16] Andrae, R. (1929) Über Knorpelknötchen am hintern Ende der Wirbelbandscheiben im Bereich des Spinalkanals. *Beitr path Anat* **82**, 462.
[17] Von Luschka, H (1858) *Die Halbgelenke des menschlichen Körpers* Berlin.
[18] Schmorl, G (1929) Über Knorpelknötchen an der Hinterfläche der Wirbelbandscheiben. *Fortschr Röntgenstr* **40** 629
[19] Andrae, R. (1929) Über Knorpelknötchen am hintern Ende der Wirbelbandscheiben im Bereich des Spinalkanals. *Beitr path Anat* **82**, 462.

5 Local Oedema.

Extrusion of nuclear tissue is associated with local swelling both in the region of the displaced material and of the involved nerve root. Variations in the degree of swelling may account for alterations in the patient's symptoms. Falconer and others[14] have carried out serial myelograms and their findings suggest that root oedema can subside materially while the disc protrusion remains unaltered.

6 Shrinkage of Nuclear Protrusion.

There is no doubt that a nuclear protrusion fibroses and shrinks quite rapidly and the high water content of nuclear tissue makes it possible for such a protrusion to shrink to about one-quarter of its original size. This is of course associated with an alteration in pressure symptoms.

7 Adaptation of Roots to Pressure and Tension.

It is probable that the roots in their extrathecal course may adapt themselves to an increase in tension or pressure produced by a nuclear protrusion. Such adaptation is associated with a decrease in the patient's symptoms particularly with a decrease in the "fast" type of pain and such an improvement would persist until a further increase in the size of the protrusion produced another rise in root tension.

8. Variations in Root Protrusion Relationship.

A root may alter its relationship to a nuclear protrusion so that a decrease in root tension results. For example a root may slip off the summit of a protuberance or move from one side of it to another because of a change in the patient's posture. Such alterations might be associated with changes in root symptoms.

9 Root Lengthening.

It has been suggested that roots under abnormal tension may actually lengthen. Experiments by Dawbin and others[15] showed that when small blocks of wood or wax were placed under the lower lumbar roots in cats so that these were rendered taut, actual lengthening of the roots occurred so that when re-examined two weeks later they were found to be slack.

10 Nerve Adherence in Later Stages.

A nerve root stretched by a nuclear protrusion quickly adheres to the protrusion. As the nuclear tissue fibroses and shrinks the adhesions organise and the root becomes more and more firmly bound down to the abnormal disc. At this stage the adherent root is very liable to traction injury on movement, either active

[14] Falconer, M. A., McGeorge, M., & Begg, A. C. (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J. Neurol. Neurosurg. Psychol.*, 11, 13-26.
[15] Dawbin, W., Cole, D. S., & Glasgow, G. L., quoted by Falconer, M. A., McGeorge, M., & Begg, A. C. (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J. Neurol. Neurosurg. Psychol.*, 11, 13-26.

or passive of the lumbar spine or affected leg and any such stretching is associated with a recurrence of symptoms

11 **Permanent Changes in the Nerve Root.**

As a result of long-continued pressure permanent degenerative changes may take place in an extrathecal root. With the complete loss of function of some sensory fibres pain sensation may disappear

With all these possible sources of irregular variation in the patient s symptoms it is not surprising that a lumbar disc lesion should be episodic in its clinical manifestations It is probable that most if not all of these factors affect the course of each individual case in its various stages

'NORMAL' OR SYMPTOMLESS DISC PROTRUSIONS

It is convenient at this stage to consider the evidence as to whether or not symptomless or normal posterior displacement of nuclear substance can occur The work of Andrae[16] is constantly quoted to support the contention that such displacements are fairly common and often unassociated with symptoms.

These symptomless protrusions were first observed by von Luschka[17] re discovered by Schmorl[18] and further investigated by Andrae.[19] The last named reports that he found posterior nuclear displacements in 15 2 per cent. of 368 spines examined. These were mainly central in type lying over the central band of the posterior longitudinal ligament and were more common in females than in males (18 7 per cent. as opposed to 11 5 per cent.) Protrusions were mainly seen in the lower dorsal and upper lumbar regions and were most usual over the age of 50 never being observed under the age of 30 They were always associated with degenerative changes in the disc itself never projected more than 4 mm into the spinal canal and were apparently unassociated with symptoms.

It seems clear that these lesions, while possibly related to differ in site in age incidence, in size and in their effects from degenerative changes as seen in the lower lumbar discs. It is certain that no evidence has as yet been advanced to show that degenerative lesions of the lower lumbar discs with associated posterior displace ment of nuclear material commonly occur without producing symptoms. In the opinion of the author these symptomless protrusions are one of those medical myths which arise from a misinterpretation or mistranslation of some original work and thereafter creep from paper to paper and text book to text book in seeming perpetuity

[16] Andrae, R (1929) Über Knorpelknotchen am hintern Ende der Wirbelbandscheiben im Bereich des Spinalkanals. *Beitr path. Anat.*, 82, 462.
[17] Von Luschka, H (1858) *Die Halbgelenke des menschlichen Körpers.* Berlin
[18] Schmorl, G (1929) Über Knorpelknotchen an der Hinterfläche der Wirbelbandscheiben. *Fortschr Röntgenstr* 40 629
[19] Andrae, R (1929) Über Knorpelknotchen am hintern Ende der Wirbelbandscheiben im Bereich des Spinalkanals. *Beitr path Anat* 82, 462.

5 Local Oedema.

Extrusion of nuclear tissue is associated with local swelling both in the region of the displaced material and of the involved nerve root. Variations in the degree of swelling may account for alterations in the patient's symptoms. Falconer and others[14] have carried out serial myelograms, and their findings suggest that root oedema can *subside materially while the disc protrusion remains unaltered.*

6 Shrinkage of Nuclear Protrusion.

There is no doubt that a nuclear protrusion fibroses and shrinks quite rapidly and the high water content of nuclear tissue makes it possible for such a protrusion *to shrink to about one-quarter of its original size.* This is of course associated with an alteration in pressure symptoms.

7 Adaptation of Roots to Pressure and Tension.

It is probable that the roots in their extrathecal course may adapt themselves *to an increase in tension or pressure produced by a nuclear protrusion.* Such adaptation is associated with a decrease in the patient's symptoms particularly with a decrease in the "fast" type of pain and such an improvement would persist until a further increase in the size of the protrusion produced another rise in root tension.

8 Variations in Root Protrusion Relationship

A root may alter its relationship to a nuclear protrusion so that a decrease in root tension results. For example, a root may slip off the summit of a protuberance or move from one side of it to another because of a change in the patient's posture. *Such alterations might be associated with changes in root symptoms.*

9 Root Lengthening.

It has been suggested that roots under abnormal tension may actually lengthen. Experiments by Dawbin and others[15] showed that when small blocks of wood or wax *were placed under the lower lumbar roots in cats so that these were rendered taut* actual lengthening of the roots occurred so that when re-examined two weeks later they were found to be slack.

10 Nerve Adherence in Later Stages.

A nerve root stretched by a nuclear protrusion quickly adheres to the protrusion. As the nuclear tissue fibroses and shrinks the adhesions organise and the root becomes more and more firmly bound down to the abnormal disc. At this stage the adherent root is very liable to traction injury on movement, *either active*

[14] Falconer M A., McGeorge, M., & Begg, A. C (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J Neurol Neurosurg Psychol* 11 13-26.
[15] Dawbin, W., Cole, D S., & Glasgow G L., quoted by Falconer M A., McGeorge, M & Begg, A. C (1948) Cause and mechanism of symptom production in sciatica and low back pain. *J Neurol Neurosurg Psychol*, 11 13 26

I ONSET OF SYMPTOMS

One of the most characteristic features of the syndrome is that it tends to be of an episodic nature. Attacks of pain of varying severity are followed by periods of relative or complete relief and it is only in very occasional cases that symptoms persist unchanged and unabated for more than two or three months The initial attack may take various forms in respect to the following points

Mode of Onset of Symptoms

There are three possible ways in which the first symptoms commonly appear and several less usual modes of onset

PAIN IN THE LOW BACK —This is certainly the commonest presenting symptom although estimations of the percentage of patients in which this is the initial complaint vary a little. Young[1] found that backache was the first symptom in 68 per cent. Alexander[2] in 52 per cent. and the author in 69 per cent. of their patients.

There are two distinct types of backache associated with disc lesions.

The pain may be acute severe and of sudden even of dramatic, onset. This type of pain is located in the low back and is associated with muscle spasm and difficulty in moving, the back being held rigid. The symptoms are always severe and incapacitating. Usually the patients can with difficulty get about provided sudden movements are avoided but in extreme cases the condition may be completely crippling, all attempts at movement producing an intense spasm of pain This severe pain generally begins gradually to subside within a few days of its onset and is often temporarily relieved by heat. It is usually two or three weeks before the back is normal although in some instances patients insist that the more acute symptoms disappear as suddenly as they appeared

This rather dramatic and sudden onset is a relatively common occurrence and is usually diagnosed as lumbago or acute fibrositis. In the author's view this type of onset is associated with internal derangement of an intervertebral joint, probably with locking produced by a partial displacement of a nuclear fragment.

The second type of backache associated with disc lesions is of quite a different nature. These patients complain of a dull diffuse aching in the low back, generally of gradual onset. The aching is made worse by exertion or by long periods of standing or sitting and is often relieved by rest. This pain is also episodic in nature but less markedly so than the more acute type. The chronic backache may persist more or less unchanged for several weeks or even months and the remissions are only associated with a relative degree of relief This type of initial backache, producing what Burns has described as the lame back is probably associated with a degenerating disc and may occur before rupture of the annulus and associated nuclear extrusion.

Not infrequently both types of backache occur in the same patient. Acute symptoms may follow or be followed by a more chronic backache. In these

[1] Young, R. H (1947) Protrusion of intervertebral discs. *Proc R. Soc. Med.*, 40, 233-236.
[2] Alexander G L. (1947) Prolapsed intervertebral disc. *Edinb med J.*, 54 14-29

CHAPTER VI

THE CLINICAL PICTURE IN LUMBAR DISC LESIONS

LESIONS of the lumbar intervertebral discs produce a characteristic clinical syndrome. This is not however constant or static but varies quite widely both from patient to patient and from time to time in the same patient. Because of this, a disc lesion has in the past been regarded as a rather obscure complaint and many clinicians have tended to consider any such diagnosis somewhat speculative and uncertain

It must be remembered however that degeneration of a lumbar disc with subsequent rupture of the annulus fibrosus and posterior displacement of part of the nucleus pulposus is a gradual and progressive condition and that each phase produces different signs and symptoms. Further considerable variation occurs between individual lesions notably in regard to the amount and site of the displaced nuclear tissue. These differences are associated with wide divergences in the secondary effects produced, particularly in the degree of involvement of the intra spinal nerve roots in their extrathecal course. It is therefore to be expected that lumbar disc lesions should cause signs and symptoms depending on and varying with their stage, site and nature.

The clinical syndrome produced by disc lesions may be considered from three aspects the history of the complaint as given by the patient, the physical signs elicited on examination and the results of certain ancillary investigations. Competent and careful investigations should produce sufficient evidence for accurate diagnosis not simply of the existence but of the exact site type and stage of any disc lesion which may be present.

THE PATIENT'S STORY

There are few conditions in which the patient's own description of the onset, course and nature of the symptoms is of greater clinical value. Indeed the combination and sequence of disorders affecting the low back and leg are often so typical that it would be possible to make a confident diagnosis on the history alone.

It should be remembered however that although the progressive occurrence of apparently unconnected symptoms may be of the utmost importance to the clinician such is not necessarily the case with the patient, whose attention is often fixed on the highlights of the complaint Painstaking attention and judicious questioning are usually necessary to elicit the complete story particularly when the lesion is of long standing. In compiling an accurate picture of the patient's symptoms the following points are of particular importance.

nerve roots of the cauda equina produced by the sudden retropulsion of a large amount of nuclear material Such a retropulsion may be the result of a severe injury to a previously healthy disc or of a less severe or even minor injury to a degenerate but symptomless disc Massive retropulsions are also particularly liable to occur during pregnancy or in the puerperium presumably as a result of the generalised softening of fibrous tissue which takes place during this period

In the compression syndrome type of onset pain is not usually severe the predominant features being those of partial or complete paraplegia or hemiplegia

The level at which this type of disc injury takes place varies considerably Those produced by gross violence and in which the affected disc presumably was normal prior to injury appear to be most common in the lumbo-dorsal region For example in the first recorded instance of this type of injury reported by Kocher[7] in 1896 a retropulsion of the L.1 L.2 disc with associated paraplegia was produced by a fall of 100 feet. In Middleton and Teacher s case in 1911[8] the level of the lesion was D 12 L.1 and in a series of three cases reported by Schneider[9] in 1949 the levels of the two lesions produced by car accidents were at the D 2 D 3 and the L.1 L.2 interspaces. In those patients in whom a relatively trivial injury produces a sudden massive retropulsion with associated pressure symptoms the L.4 L.5 or the L.5 S 1 discs are most commonly affected For example in the third case reported by Schneider the symptoms occurred suddenly following an attempt to run upstairs and the lesion was subsequently found at the L.4 L.5 level

The compression symptoms which occur in this type of onset depend on the level and degree of pressure on the spinal cord or cauda equina A high lesion may cause complete paralysis of both legs with associated bladder and rectal symptoms while a lower lesion in which the extrusion is unilateral may cause paralysis weakness or sensory change confined to one leg.

Although the compression syndrome type of onset may be unusual when it does occur it is of the greatest importance that it should be recognised immediately The prognosis may depend on prompt and adequate surgical treatment and patients with severe pressure and complete paralysis constitute a surgical emergency in which even a few hours delay may have serious consequences.

History of Preceding Injury

About 60 per cent. of all patients with lumbar disc lesions give a history of some form of injury before the onset of symptoms.

In between 10 and 20 per cent. the association is clear cut and often dramatic. Such patients describe some low back strain usually in the form of force applied to the flexed spine a click or the sensation of something giving way in the

[7] Kocher T (1896) Die Verletzungen der Wirbelsaule zugleichal Beitrag zur Physiologie des menschlichen Ruckenmarks. *Mit Gren.eb Med Chir.*, 1 420.
[8] Middleton G S., & Teacher J H (1911) Injury of the spinal cord due to rupture of an intervertebral disc during muscular effort. *Glasg med J.*, 76, 1-6
[9] Schneider, R. C. (1949) Acute traumatic posterior dislocation of an intervertebral disc with paralysis. *J Bone Jt Surg.*, 31A, 556

circumstances the patient often forgets or disregards the more chronic and less severe symptoms and may omit to mention them unless closely questioned on this point.

SCIATIC PAIN.—Pain referred to the distribution of the sciatic nerve and unaccompanied by any discomfort in the low back may be the initial symptom of a lumbar disc lesion. This is the second most common type of onset and has been observed by Young[3] in 24 per cent., by Alexander[4] in 32 per cent. and by the author in 20 per cent. of patients. Sciatic pain is the first symptom of which the patient actually complains in a considerably higher percentage of all lumbar disc lesions, but in many of these it becomes clear on careful questioning that this pain has, in fact, been preceded by minor low back symptoms which have been ignored or forgotten.

As with low back pain, the nature of the initial attack of sciatic pain may vary widely.

The most common form of onset is an insidious and gradually increasing discomfort, starting first as a dull, unpleasant ache in the buttock and posterior aspect of the thigh, later increasing in intensity and spreading below the knee to the calf, ankle and foot. Occasionally this mode of spread is reversed and pain is first felt in the region of the heel or ankle, subsequently spreading up the leg.

Less commonly sciatic pain is very severe from the outset, the whole distribution of one root being affected. This pain occurs suddenly and while it is never quite so agonising or crippling as the acute pain which may occur in the low back, it is more constant and cannot even temporarily be relieved by rest or by the assumption of any particular posture.

BACKACHE AND SCIATICA.—In the third and least common of all the usual types of onset, backache and sciatic pain occur simultaneously. This presenting syndrome has been observed in 8 per cent. of patients by Young,[5] 16 per cent. of patients by Alexander,[6] and in the author's series it occurred in 11 per cent. of all patients.

Most commonly the simultaneous onset of backache and sciatica is a sudden and dramatic phenomenon occasioned or precipitated by an injury or a flexion strain on the spine. Pain, both in the back and the leg, is severe and this type of onset is probably associated with a sudden annular rupture and immediate posterior displacement of a considerable amount of nuclear tissue.

Less commonly the backache and sciatic pain, although occurring simultaneously, are of gradual onset. In these circumstances there is not necessarily an equal amount of pain in both the low back and the leg. Quite often one is the site of the most troublesome symptoms, pain in the other, although present, being relatively trivial.

LESS COMMON MODES OF ONSET.—The less common modes of onset of symptoms due to lumbar disc lesions are associated with severe pressure on the

[3] Young, R. H. (1947). Protrusion of intervertebral discs. *Proc. R. Soc. Med.*, 40, 233-236.
[4] Alexander, G. L. (1947). Prolapsed intervertebral disc. *Edinb. med. J.*, 54, 14-29.
[5] Young, R. H. (1947). Protrusion of intervertebral discs. *Proc. R. Soc. Med.*, 40, 233-236.
[6] Alexander, G. L. (1947). Prolapsed intervertebral disc. *Edinb. med. J.*, 54, 14-29.

The same difficulty arises in assessing the value of any other form of treatment during the initial attack but it is significant that rest is by far the most effective measure at this stage. The patient who is confined to bed either by severe pain or on medical advice usually recovers quite quickly and any premature return to activity is often associated with some recurrence of symptoms.

2. SUBSEQUENT PROGRESS

The subsequent history of a patient with a lumbar disc lesion is usually fairly characteristic. Intermittent attacks of pain and disability are punctuated by periods of relative or complete relief Without treatment symptoms tend to become increasingly severe and the attacks occur more frequently Considerable variation in detail occurs within this broad outline however and the progressive nature of the complaint is not always obvious nor is the deterioration in the patient s condition necessarily rapid or regular These variations are worth considering in some detail.

Frequency of Attacks.

Although attacks tend to become more frequent it is unusual to find that these occur in a regular manner In many instances there is an interval of months or even years between episodes and the lesion appears to lie dormant during this time and to recur either spontaneously or as a result of some injury or exertion This long interval may follow the initial attack or may occur later in the course of the disease.

Once the patient s condition is on the down-grade, however attacks commonly occur more and more frequently and become more liable to take place without obvious provocation.

In the final stages of the condition when secondary changes have become established periodicity becomes a less marked feature and some symptoms usually persist continuously

Nature of Low Back Symptoms.

The nature of the low back symptoms varies between sudden attacks of acute, incapacitating pain and chronic backache exacerbated by exertion Both types of symptoms may be present, the most common combination being chronic backache punctuated by bouts of acute pain. In the later stages when intervertebral arthritis has become established discomfort or pain in the low back is usually constantly present.

Nature of Root Symptoms.

In a small percentage of patients with lumbar disc lesions symptoms are permanently confined to the low back and sciatic pain does not occur When they do occur there is a wide variation in the nature of root symptoms both from patient to patient and from time to time in the same patient. Most commonly sciatic

lumbar region and the immediate onset of symptoms which are usually severe from the outset. While the precipitating trauma may be quite severe or may occur during violent muscle effort, quite often the injury takes place while the patient is engaged in some very ordinary and not particularly strenuous activity Occasionally some quite trivial occurrence, such as coughing while in a stooping position or turning over in bed may precipitate symptoms.

In the remainder of patients giving a history of injury however the connection between the actual trauma and the onset of symptoms is not nearly so obvious. There may be a delay of some hours or even days before symptoms become apparent, and these may develop very gradually Close questioning is often necessary before such patients vouchsafe a history of some injury or jarring of the back dismissed as trivial at the time and subsequently forgotten occurring a short time before the onset of symptoms.

About 40 per cent. of all patients with lumbar disc lesions give no history of any injury whatever to the lumbar spine.

In the author's view a history of injury is not necessarily a very important factor in the diagnosis of lumbar disc lesions. Certainly the dramatic association of something clicking or giving way in the low back with consequent immediate and severe symptoms is strong presumptive evidence of such a lesion in the comparatively small percentage of patients in which such a sequence of events takes place. The absence of such a history however or indeed of a history of any injury in no way diminishes the possibility of the existence of a disc lesion.

Duration of Initial Attack.

The symptoms produced by lumbar disc lesions invariably vary widely in intensity and usually remit completely from time to time and this episodicity is one of the essential and characteristic features of the disease.

The duration of the initial symptoms varies widely but on the whole the first attack even if untreated tends to be less severe and less prolonged than subsequent exacerbations.

In those patients in whom severe low back pain is the presenting feature the intense symptoms usually start to diminish and change to chronic discomfort quite rapidly When gradually increasing backache is the initial symptom this tends to become more severe at first and then to die away gradually though without ever disappearing completely In patients in whom back pain is associated with sciatica or in whom sciatica alone is present much the same sequence of events takes place Generally speaking the sciatic pain is a little less fluctuant and less liable to disappear altogether than the low back pain symptoms, although this is by no means invariably the case.

The effects of treatment in the initial stages is of some importance. When such patients consult their medical practitioner an initial diagnosis of fibrositis lumbago or sciatica is usually made. Physiotherapy in the form of heat diathermy or massage is prescribed and any subsequent remission of symptoms is attributed by patient or doctor to these measures probably without justification.

ment, first from their own doctor or from the local hospital and then from unqualified manipulators osteopaths or bone setters without having derived any permanent benefit. They have come to accept their affliction and do not trouble to seek further medical advice. It is these people who represent many of the cures which are said to have occurred with time.

In the later stages the symptoms are usually fairly typical Arthritis has become established and there is a certain amount of low back pain which is made worse by activity or by long periods of sitting or standing. Any strenuous occupation causes a sharp exacerbation of pain and is therefore avoided From time to time exacerbations occur spontaneously and the patient then rests until his low back becomes more comfortable.

As far as the sciatica is concerned permanent changes have probably taken place in the nerve root and some sensory diminution and loss of muscle power is established and constant. Pain may well have decreased with the establishment of permanent changes but at the same time a certain amount of dull aching and sciatica are constantly present and are subject to exacerbations as a result of exertion.

The patient s carriage posture and gait are often abnormal and they suffer from a very real permanent disability In most cases their life has been so adjusted that they are able to carry on some form of work in spite of their disability but they are by no means normal nor could their condition be accepted as a desirable or satisfactory end result

pain first occurs after the low back pain has been present for some weeks months although as has been pointed out, sciatica, either alone or in associati with backache may be a presenting feature of the lesion The whole of t distribution of the involved root is not often affected at first. Pain may be felt in t buttock and posterior aspect of the thigh and later spreads below the knee althou in some instances this incidence is reversed and pain is first felt in the region the ankle or heel.

Most commonly sciatic pain first occurs in and is confined to one leg and the majority of patients symptoms never affect both legs. When the retropuls nuclear material comes into contact with the roots on both sides however bo legs are affected. Bilateral root pressure may occur from the first or may be a la phenomenon When a central or bilateral lesion is present sciatica may be altern ing first one and then the other leg being affected.

The other effects of root involvement, sensory change and motor weakne are not usually noticed by the patient unless and until they become very marke

When pressure on the root has been prolonged and severe, permanent chang in the nerve itself take place and these are often associated with a diminution disappearance of pain and an increase in the motor and sensory changes

From time to time patients are seen in whom root compression has be sufficiently severe to produce physiological root section immediately nuclear retr pulsion has taken place. These patients have no pain but complain of weakne and numbness of one leg the exact areas affected depending on the level of t root involved.

Root symptoms tend to be more persistent than spinal symptoms. Son remissions of sciatic pain usually do occur but on the whole this is much le markedly episodic in nature than is the low back pain

3 LATE STAGES OF UNTREATED DISC LESIONS

It has been said that disc lesions tend to recover spontaneously with tim This view has been based on the assumption that the large majority of patien previously diagnosed as sciatica and treated in various ways for this condition we in fact suffering from lumbar disc lesions. These patients were said to recov spontaneously after a period of months or years although their immediate respon to treatment was often unsatisfactory No conclusive figures have ever been pr duced to support this argument and the patients were assumed to have recovere because they ceased to attend hospital out patients or to consult their medic adviser

In fact there does not seem to be any reason at all to suppose that an material proportion of patients suffering from untreated disc lesions do recove spontaneously There may be periods of relative or complete recovery but relaps almost invariably occur There is no small community or even street in th country in which there are not one or two individuals who have been martyrs to lumbago or sciatica for the major part of their lifetimes. These peopl who have never been diagnosed as disc lesions have run the whole gamut of treat

ment first from their own doctor or from the local hospital and then from unqualified manipulators osteopaths or bone setters without having derived any permanent benefit. They have come to accept their affliction and do not trouble to seek further medical advice. It is these people who represent many of the cures which are said to have occurred with time.

In the later stages the symptoms are usually fairly typical Arthritis has become established and there is a certain amount of low back pain which is made worse by activity or by long periods of sitting or standing. Any strenuous occupation causes a sharp exacerbation of pain and is therefore avoided From time to time exacerbations occur spontaneously and the patient then rests until his low back becomes more comfortable.

As far as the sciatica is concerned permanent changes have probably taken place in the nerve root and some sensory diminution and loss of muscle power is established and constant. Pain may well have decreased with the establishment of permanent changes but at the same time a certain amount of dull aching and sciatica are constantly present and are subject to exacerbations as a result of exertion.

The patient's carriage, posture and gait are often abnormal and they suffer from a very real permanent disability In most cases their life has been so adjusted that they are able to carry on some form of work in spite of their disability but they are by no means normal nor could their condition be accepted as a desirable or satisfactory end result.

CHAPTER VII

THF CLINICAL PICTURE IN LUMBAR DISC LESIONS

(Continued)

GENERAL FINDINGS, EXAMINATION OF LUMBAR SPINE

GENERAL FINDINGS

A METHODICAL and complete routine examination is necessary in all patients complaining of low back pain with or without sciatica. Even the negative findings should be carefully noted as full clinical records are necessary to assess the patient's progress and determine the effects of treatment.

It is desirable to examine the patient and note the findings in an ordered manner and the following points should always be observed so that the records may be uniform and complete.

1 Posture.

The patient in the throes of an acute attack or in whom symptoms are severe assumes a characteristic posture. The lumbar spine is held rigid in a flattened position (Plate 4A) while the dorsal and cervical spines are slightly flexed The whole trunk is tilted forward at the hips and the affected leg is held with the hip in flexion the knee in flexion and the ankle in plantar flexion only the toes resting on the ground. If a marked spinal scoliosis is present this may be obvious one hip and one shoulder being unduly prominent (Plates 3D and 4D). The whole effect is that the patient is bent forward the lumbar spine is flattened and the affected leg is drawn up.

2. Movements and Gait.

Patients with severe symptoms have a distinctive gait and move in a typical way Their whole attention appears to be concentrated on avoiding any jarring of the lumbar spine or stretching of the affected sciatic nerve. All movements are slow and deliberate and accompanied by obvious discomfort, and the lumbar spine may be supported by one hand pressed into the lower back. Particular difficulty is experienced in sitting down or getting up or in lying flat on a bed or examination couch

On walking the hip and knee of the affected leg are flexed and dorsiflexion of the ankle is avoided by supporting the body weight on the toes and forefoot without the heel coming into contact with the ground.

3 Location of Back Pain

Back pain is located by the patient to the lower lumbar region and is not often accurately localised. When acute symptoms are present the patient states

EXAMINATION OF THE SPINE

It cannot be too much emphasised that the diagnosis of a lumbar disc lesion is based mainly on the clinical examination of the spine. Here the signs associated with an active disc lesion are typical constant and present in some degree in all patients. The following are the most important physical signs peculiar to this region.

1 Muscle Spasm.

Spasm of the erector spinae muscles in the lumbar region is a constant and reliable sign in lumbar disc lesions. The spasm is both visible and palpable and is often more marked on one side than on the other

2. Flattening of the Lumbar Spine.

Normally when standing erect the lumbar spine is in a position of lordosis. The degree of lordosis is more marked in the female than in the male and varies a good deal from individual to individual, but it is always present sufficiently to be obvious on inspection. When an active lumbar disc lesion exists the lordosis disappears and in the erect position the lumbar spine is flattened This flattening *is a constant and important sign* and is always readily appreciable (*Plates* 3A and 4A).

3 Postural Scoliosis.

In certain phases of most disc lesions the spine is held in a position of scoliosis (Plates 3D and 4D). This postural or sciatic scoliosis is probably associated with extrathecal root tension produced by retropulsed nuclear material and is not therefore a constant clinical finding. *It does not usually occur in the first stage of any* disc lesion and is inconstant in the third stage, while in a completely central lesion it may not appear at any time. The lumbar convexity may be either towards or away from the side on which the lesion is situated depending on whether the protrusion is on the inner or outer side of the involved root (Fig. 37). *In some* cases the scoliosis is alternating and may change suddenly from one side to the other This phenomenon is almost certainly associated with the taut root slipping over the summit of the nuclear tumour The degree of scoliosis varies a great deal it may be gross and obvious or it may only be detectable on careful examination. Sometimes a scoliosis which is not present in the erect position may appear when the spine is flexed

4 Movements.

In the presence of a disc lesion there is a characteristic decrease in the mobility of the lumbar spine which is reflected in the range of active spinal movement Broadly speaking flexion and extension are limited and *painful while lateral flexion* and rotation are relatively free. This finding is of great value in differential diagnosis as it is in striking contrast to the generalised and uniform stiffness and pain on all movements which occur in association with certain other lesions.

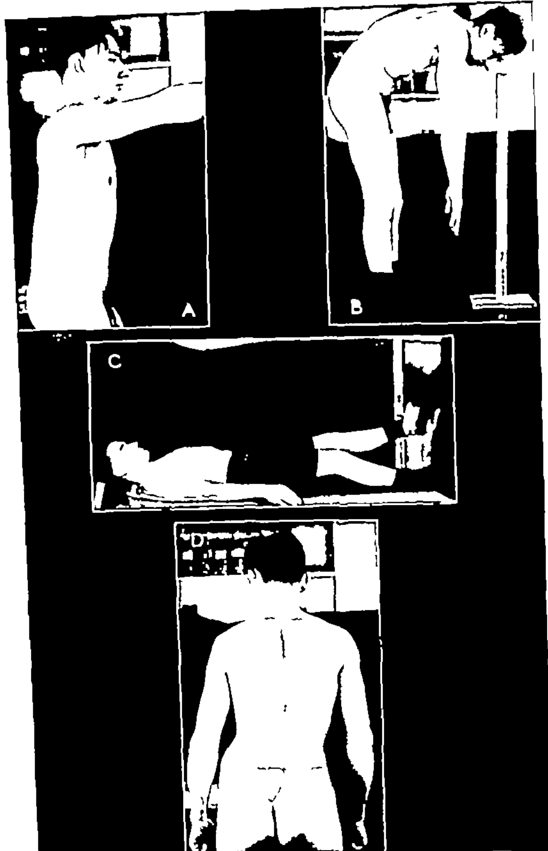


PLATE 3

Photographic record of patient

The photographs show the posture (A and D) the range of spinal flexion (B) and the range of straight-leg raising on the affected side (C). (This patient had failed to respond to conservative treatment. At operation a lesion of the L.4 L.5 disc was found with a nuclear protrusion on the left side involving the fifth left lumbar root.)

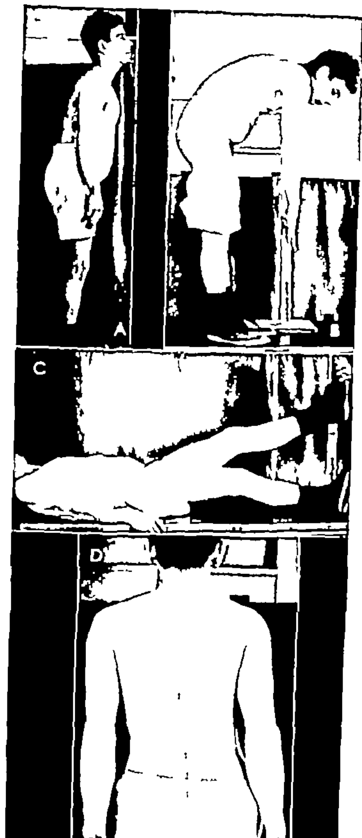


PLATE 4

Photographic record of patient

The photographs show the posture (A and D) the range of spinal flexion (B) and the range of straight leg raising on the affected side (C). (This patient had failed to respond to conservative treatment. At operation a lesion of the L5 S.1 disc was found with a nuclear protrusion on the right side involving the first left sacral root.)

The degree of limitation of flexion and extension depends on the nature and condition of the affected disc. In the acute phase of a severe lesion these movements are lost completely and any attempt to flex or extend the rigid lumbar spine causes acute pain The term a locked back is often applied to this phase and describes the condition graphically the whole appearance being closely comparable to that associated with true locking of any other joint Even in this acute phase, however the power of lateral flexion and of rotation is not completely lost.

The several movements of the spine are examined individually and both their range and nature are noted The manner in which the individual movements are carried out is of particular importance The normal spine moves smoothly and freely without pain or muscle spasm In the presence of a disc lesion the range of movement may be fairly full but the back may move slowly and jerkily with accompanying spasm of the erector spinae muscles of the lumbar region Observation of the nature is of as much diagnostic importance as the measurement of the actual range of movement.

(*a*) FLEXION —The patient stands erect with the heels together the knees extended and the arms straight. Keeping the knees straight and the arms extended the spine is bent forward and the range of flexion is recorded by observing the distance between the finger tips and the ground at the extreme of this movement (Plates 3B and 4B). The manner in which flexion is carried out is also observed. In the presence of a disc lesion the lumbar spine is held rigid and flexion takes place at the hips and in the dorsal and cervical regions. Quite often the spine assumes a position of scoliosis as soon as flexion is commenced or a scoliosis previously present becomes accentuated. In some cases a hitch occurs about the middle range of flexion. At this point something appears to restrict movement and to be avoided by slight rotation of the spine. In some cases this hitch is very obvious and the patient complains of a sudden stab of pain at this point. The manner in which the patient extends the spine from the fully flexed position should also be observed. Quite often particularly in the less acute cases this is more painful than flexion itself and a typical hitch, absent or unnoticeable on flexion may be obvious when the flexed spine is slowly extended.

(*b*) EXTENSION —The patient is asked to stand in the erect position and then to bend backwards as far as possible. A varying range of extension can take place in a normal spine, this movement being produced mainly by an accentuation of the normal lumbar lordosis. When a disc lesion is present, however extension is grossly diminished or completely absent and any attempt to produce or force this movement causes pain.

(*c*) LATERAL FLEXION —From the erect position with the arms by the sides lateral flexion may be measured by the distance between the extended finger tips and the ground or by the point reached on the leg at the extremes of this movement. In the presence of a lumbar disc lesion lateral flexion is relatively much freer than forward flexion or extension, although some slight limitation and pain at the extremes of movement are usual This limitation and pain are not necessarily symmetrical but may be more marked on one side than the other This finding

5

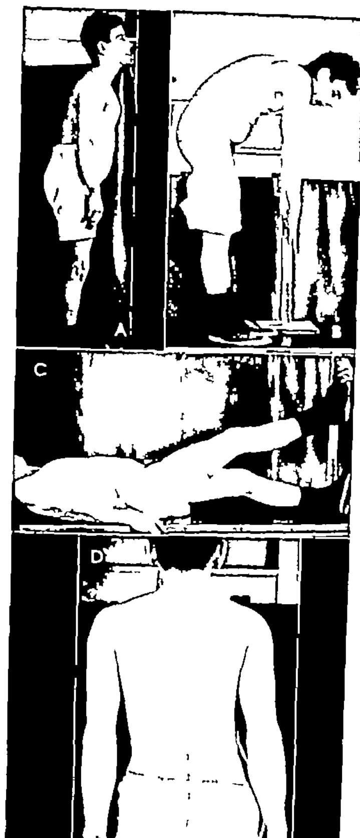


Plate 4

Photographic record of patient

The photographs show the posture (A and D) the range of spinal flexion (B) and the range of straight leg raising on the affected side (C). (This patient had failed to respond to conservative treatment. At operation a lesion of the L.5 S.1 disc was found with a nuclear protrusion on the right side involving the first left sacral root.)

The degree of limitation of flexion and extension depends on the nature and condition of the affected disc. In the acute phase of a severe lesion these movements are lost completely and any attempt to flex or extend the rigid lumbar spine causes acute pain The term a locked back is often applied to this phase and describes the condition graphically the whole appearance being closely comparable to that associated with true locking of any other joint Even in this acute phase, however the power of lateral flexion and of rotation is not completely lost.

The several movements of the spine are examined individually and both their range and nature are noted The manner in which the individual movements are carried out is of particular importance. The normal spine moves smoothly and freely without pain or muscle spasm In the presence of a disc lesion the range of movement may be fairly full but the back may move slowly and jerkily with accompanying spasm of the erector spinae muscles of the lumbar region Observation of the nature is of as much diagnostic importance as the measurement of the actual range of movement.

(*a*) FLEXION —The patient stands erect with the heels together the knees extended and the arms straight. Keeping the knees straight and the arms extended the spine is bent forward and the range of flexion is recorded by observing the distance between the finger tips and the ground at the extreme of this movement (Plates 3B and 4B). The manner in which flexion is carried out is also observed. In the presence of a disc lesion the lumbar spine is held rigid and flexion takes place at the hips and in the dorsal and cervical regions. Quite often the spine assumes a position of scoliosis as soon as flexion is commenced or a scoliosis previously present becomes accentuated. In some cases a hitch occurs about the middle range of flexion At this point something appears to restrict movement and to be avoided by slight rotation of the spine. In some cases this hitch is very obvious and the patient complains of a sudden stab of pain at this point. The manner in which the patient extends the spine from the fully flexed position should also be observed. Quite often particularly in the less acute cases this is more painful than flexion itself and a typical hitch absent or unnoticeable on flexion may be obvious when the flexed spine is slowly extended.

(*b*) EXTENSION —The patient is asked to stand in the erect position and then to bend backwards as far as possible. A varying range of extension can take place in a normal spine this movement being produced mainly by an accentuation of the normal lumbar lordosis. When a disc lesion is present however extension is grossly diminished or completely absent and any attempt to produce or force this movement causes pain

(*c*) LATERAL FLEXION —From the erect position with the arms by the sides lateral flexion may be measured by the distance between the extended finger tips and the ground or by the point reached on the leg at the extremes of this movement. In the presence of a lumbar disc lesion lateral flexion is relatively much freer than forward flexion or extension although some slight limitation and pain at the extremes of movement are usual. This limitation and pain are not necessarily symmetrical but may be more marked on one side than the other This finding

is not constantly related to the side of a unilateral lesion, however as movement either towards or away from the affected side may be abnormal depending on the relationship of the lesion to the corresponding extrathecal nerve root.

(*d*) ROTATION —With the patient in the erect position and the feet together and pointing directly forwards rotation of the spine is judged by turning the head and shoulders as far as possible first in one direction and then in the other From this position the shoulders can normally be turned through more than 90 degrees, the range of rotation being greater in tall thin people than in stocky thickset individuals. Rotation is the least affected of all spinal movements, since it does not take place in the lumbar spine. In the presence of a lumbar disc lesion and even in patients with acute symptoms a full range of rotation is usually possible. Pain or discomfort located to the lower lumbar region at the extremes of rotation in one or both directions is not an unusual finding however Rotation is probably best measured by the number of degrees through which the shoulders turn, although this movement depends too much on the judgment of the observer to be completely accurate

5 **Local Tenderness.**

Points of local tenderness either to light or deep pressure should be sought in the lumbar region This examination is carried out both with the patient in the erect and in the prone position

When a lesion of one of the lumbar intervertebral discs is present it is usual to find deep tenderness about two inches from the middle line at the level of the lesion this tenderness being most marked on the side of the nuclear protrusion should this be unilateral.

An occasional finding of some importance is an area of acute tenderness to light pressure in the region of the posterior aspect of one sacro-iliac joint or along the posterior half of the iliac crest. This tenderness is usually associated with pain felt in the same area and is often a source of diagnostic confusion. The presence of such an area of tenderness in association with a lumbar disc lesion is probably due to extrathecal root irritation particularly affecting the posterior primary division of the root.

6 **Effects of Local Percussion.**

Some observers attach particular diagnostic importance to the effects produced by percussing the flexed lumbar spine. They consider that in the presence of a disc lesion this percussion produces both local pain and pain referred to the distribution of any affected lumbar nerve root. In the author's experience this is not a uniformly constant clinical sign although when it is present it is strong confirmatory evidence of a disc lesion

CHAPTER VIII

THE CLINICAL PICTURE IN LUMBAR DISC LESIONS

(*Continued*)

EXAMINATION OF LEGS

WHILE the diagnosis of the presence of a lumbar disc lesion is based mainly on the clinical findings in the lumbar spine, the location of the level of this lesion and an estimation of the bulk and exact site of displaced nuclear tissue depends on examination of the legs.

With the possible exception of some part of the referred pain the symptoms and signs referable to the lower limbs are produced by irritation of or pressure on the extrathecal nerve roots. Most commonly one root is involved, but a single lesion may involve two adjacent roots on the same side or opposite roots at the same level (Fig. 34). If a double lesion is present the root involvement may of course, be even more complex and in some types of central protrusion the roots are not affected at all. By careful clinical examination it is possible to decide which roots are involved and to make some estimation of the nature and degree of root interference.

The following are the most important points in the examination of the leg.

SITE OF REFERRED PAIN

The patient is asked to point out the exact areas in which pain of any kind is or has been present. Most patients have no difficulty in doing this but the finding is so important that great trouble should be taken to define these areas as accurately as possible.

Referred pain due to root irritation is felt in the cutaneous distribution of the root involved and the question of dermatome segments will be discussed more fully in connection with the sensory changes which may be present. The position is complicated, however by the possibility of the peripheral radiation of deep or sclerotogenous pain

Deep pain is of a different character from cutaneous pain being dull aching and poorly localised and its distal radiation is, as Inman and Saunders[1] have pointed out, related to mesodermal elements connected with the skeleton and not to dermatome segments.

These mesodermal elements are mainly represented by the skeletal muscles and referred deep pain is felt in the muscles arising from the same embryonic level or more accurately deriving their nerve supply from the motor fibres of the nerve root of the same embryonic level as the affected disc.

[1] Inman, V T., & Saunders, J B de C. M (1947) Anatomic-physiological aspects of injuries to the intervertebral disc. *J Bone Jt Surg* 29 2.

The academic determination of the exact dermatomal or myotomal distribution of referred pain is a matter of some complexity and at first sight there appears to be no relationship between the corresponding myotomes and dermatomes. In practice however a fairly simple scheme may be devised to correlate the level of the disc lesion and the site of referred pain whether this be referred deep pain or pain produced by root irritation.

As has been pointed out in Chapter II from the segmental point of view the L.5 S 1 disc and the mesodermal elements in the legs supplied by the first sacral nerve roots are of the same embryonic level and the same is true of the L.4 L.5 disc and the structures supplied by the fifth lumbar root, a similar relationship holding good between the higher discs and roots 'Deep or sclerotogenous pain originating from these discs would if referred to the legs, be felt mainly in the muscle groups supplied by the corresponding roots.

Referred pain due to root irritation is felt in the dermatome supplied by the root involved. Lesions of the lower lumbar discs most commonly affect those roots in direct anatomical contact in their extrathecal course with the abnormal disc. The first sacral roots are in close relationship with the L 5 S.1 disc, the fifth lumbar roots with the L.4 L.5 disc, the fourth lumbar roots with the L.3 L.4 disc the third lumbar roots with the L.2 L.3 disc and the second lumbar roots with the L.1 L.2 disc.

When a lesion of the L.5 S 1 disc produces pain referred to the legs this pain may be felt either in the myotome supplied by the first sacral root if it is deep pain or in the dermatome supplied by the first sacral root if it is associated with root irritation. In a similar way the L.4 L.5 disc is related to the fifth lumbar root and the upper lumbar discs with corresponding roots.

From the practical point of view it is not necessary to differentiate between these two different types of referred pain although it is often possible to do so It is sufficient to decide if the referred pain is of monoradicular distribution and then to determine with which root and therefore with which disc it is associated The vast majority of disc lesions occur in the lower two lumbar discs, a small percentage in the L.3 L.4 disc, and only in very rare cases does a lesion of the upper two discs exist. In those patients in whom referred pain is present it is therefore usually only necessary to decide if the fourth lumbar fifth lumbar or first sacral root is involved.

The method of localisation to be described is extremely simple but the results as confirmed at operation are sufficiently accurate to compare favourably with any more complicated technique.

Using this method referred pain is considered of no localising value unless it is felt below the knee. When pain is felt below the knee the areas corresponding to the various roots are indicated in Table II

Using this simple chart it is not difficult to relate referred pain below the knee to one of the three broad areas described. This indicates the root involved and localises the site of the disc lesion with very considerable accuracy

The pain does not necessarily extend over the whole of one area but may be confined to a comparatively small region within the area. This is particularly true of superficially referred pain which may only be felt in a small patch of skin Common sites for such painful patches are the antero-lateral aspect of the ankle when the fifth lumbar root is involved and the posterior aspect of the heel when the first sacral root is irritated The principle of root localisation holds good however whether the whole or part of an area is affected.

TABLE II

Root	*Site of Pain*	*Myotomal and Dermatomal Levels*
4th Lumbar (L.3 L.4 disc)	Anterior or antero-medial aspect of leg below the knee	*Dermatome* Skin of the antero-medial aspect of leg below knee (probably variable). *Myotome* Anterior tibial muscles (fourth and fifth lumbar roots).
5th Lumbar (L.4 L.5 disc)	Antero-lateral aspect of leg below the knee Dorsum of foot.	*Dermatome* Antero-lateral aspect of leg below knee and dorsum of foot *Myotome* Anterior tibial (fourth and fifth lumbar roots) and peroneal (fifth and first sacral roots) muscles.
1st Sacral (L.5 S.1 disc)	Posterior aspect of leg below knee. Sole of foot.	*Dermatome* Posterior aspect of calf and sole of foot. *Myotome* Muscles of calf (first and second sacral roots)

It is true that the areas described are not exact and that some overlap occurs. Difficulties may also arise in a few patients, particularly when pain is felt *only in* the postero-lateral aspect of the calf and may therefore be due either to fifth lumbar or first sacral root involvement. Nonetheless some such simple chart is of great value in the localisation of the level of the affected disc.

TYPE AND INTENSITY OF PAIN

It has been pointed out already that pain referred to the legs is of two types.

Deep referred pain is of a dull aching character and is poorly localised by the patient. It appears to arise deep within the limb and is not associated with the skin or superficial structures. Deep pain tends to be constant in character and although it may be made worse by exertion exacerbations occur gradually

Superficial pain on the other hand is sharp well localised and appears to originate in the skin and subcutaneous tissues. Superficial pain is liable to sudden sharp variations, and intense and transient spasms or stabs of pain may occur in association with anything which causes a sudden rise in intrathecal tension or stretching of the nerve roots

The severity of referred pain whether superficial or deep depends to some extent on the nature of the disc lesion

The academic determination of the exact dermatomal or myotomal distribution of referred pain is a matter of some complexity and at first sight there appears to be no relationship between the corresponding myotomes and dermatomes. In practice, however a fairly simple scheme may be devised to correlate the level of the disc lesion and the site of referred pain, whether this be referred deep pain or pain produced by root irritation.

As has been pointed out in Chapter II from the segmental point of view the L.5 S.1 disc and the mesodermal elements in the legs supplied by the first sacral nerve roots are of the same embryonic level, and the same is true of the L.4 L.5 disc and the structures supplied by the fifth lumbar root, a similar relationship holding good between the higher discs and roots. Deep or sclerotogenous pain originating from these discs would if referred to the legs, be felt mainly in the *muscle groups supplied by the corresponding roots.*

Referred pain due to root irritation is felt in the dermatome supplied by the root involved. Lesions of the lower lumbar discs most commonly affect those roots in direct anatomical contact in their extrathecal course with the abnormal disc. The first sacral roots are in close relationship with the L.5 S.1 disc, the fifth lumbar roots with the L.4 L.5 disc, the fourth lumbar roots with the L.3 L.4 disc, the third lumbar roots with the L.2 L.3 disc, and the second lumbar roots with the L.1 L.2 disc.

When a lesion of the L.5 S.1 disc produces pain referred to the legs this pain may be felt either in the myotome supplied by the first sacral root if it is deep pain or in the dermatome supplied by the first sacral root if it is associated with root irritation. In a similar way the L.4 L.5 disc is related to the fifth lumbar root and the upper lumbar discs with corresponding roots.

From the practical point of view it is not necessary to differentiate between these two different types of referred pain although it is often possible to do so It is sufficient to decide if the referred pain is of monoradicular distribution and then to determine with which root and therefore with which disc it is associated. The vast majority of disc lesions occur in the lower two lumbar discs a small percentage in the L.3 L.4 disc, and only in very rare cases does a lesion of the upper two discs exist. In those patients in whom referred pain is present it is therefore usually only necessary to decide if the fourth lumbar fifth lumbar or first sacral root is involved.

The method of localisation to be described is extremely simple but the results as confirmed at operation are sufficiently accurate to compare favourably with any more complicated technique.

Using this method referred pain is considered of no localising value unless it is felt below the knee. When pain is felt below the knee the areas corresponding to the various roots are indicated in Table II

Using this simple chart, it is not difficult to relate referred pain below the knee to one of the three broad areas described. This indicates the root involved and localises the site of the disc lesion with very considerable accuracy

The intensity of deep referred pain probably depends on the degree of nuclear or annular change and this pain increases as degeneration becomes more advanced and widespread. This type of pain therefore varies directly with the severity of the disc lesion.

The position in regard to superficial pain is more complex. The intensity of this pain depends directly on the degree of root irritation

Whatever the exact nature of root irritation may be it depends on contact between retropulsed nuclear material and the root in its extrathecal course. This contact depends on the amount of nuclear material displaced and on the site of the annular rupture in relation to the position of the root. The shape of the spinal canal may also profoundly affect the degree of root irritation (Fig 11) If the canal is small and particularly in the rather trefoil-shaped canal in which the root may be in a small lateral recess the root may actually be compressed between the retropulsed nuclear tissue and the bone (Fig. 33).

It must be pointed out, moreover that the degree of pain is not always uniformly or directly in proportion to the degree of root compression or tension Severe compression or even strong tension may cause a complete paralysis of all root function without any associated sensation of pain

In general, however the intensity of referred superficial pain is some indication of the amount and site of the displaced nuclear material and may also be affected by the size and shape of the spinal canal. Root compression or tension of sufficient severity to produce paralysis is not necessarily associated with pain

STRAIGHT LEG RAISING AND ALLIED TESTS

Straight leg raising is one of the simplest and most reliable clinical methods of detecting sciatic root irritation It also has a quantitative value and is a most useful means of assessing both the severity and the progress of a disc lesion

The straight leg raising test was first described by Forst,[3] who was a pupil of Lasègue. Although Forst attributed it to his teacher Lasègue[3] himself actually described the less valuable hip flexion knee extension test.

To carry out the straight leg raising test, the patient lies completely supine with the knees in full extension and the ankles in plantar flexion The examiner supports one leg and raises it by flexing the hip the position of the knee and ankle remaining unchanged Normally it is possible to raise the leg in this manner through about 90 degrees without causing the patient any discomfort other than a feeling of tension in the hamstrings and behind the knee at the extremes of movement.

In the presence of a lesion of one of the lower lumbar discs in which posterior displacement of nuclear tissue with involvement of the fifth lumbar or first sacral roots has occurred the angle through which the straight leg can be raised is diminished Any attempt to force the movement beyond the point of limitation

[3] Forst, J J (1881) Contribution a l'étude clinique de la sciatique Paris Thèse, No. 33
Lasègue, Ch. (1864) Considerations sur la sciatique *Arch gén Méd* 2 (Serie 6 Tome 4), 558 580.

is associated with severe pain felt in the back in the affected leg or in both In a lesion with unilateral root involvement straight leg raising is most diminished on the affected side but there is often some diminution of the range of movement of the opposite leg. The pain felt at the extremes of movement on the unaffected side is located in the back and may be referred to the affected leg

The degree of limitation of straight leg raising and the severity of the pain experienced at the extremes of movement is in direct proportion to the degree of root pressure tension or adherence which is present. By recording the angle through which the straight leg can be raised on each side the examiner has a reliable yardstick against which the subsequent progress of the lesion can be assessed

In the past the association of limitation of straight leg raising and sciatic pain has been attributed to various causes. It has been suggested that raising the straight leg was associated with movement of the lumbo-sacral or sacro-iliac joints and that these joints were the source of the pain felt at the extremes of movement. It has also been suggested that the pain is due to stretching already spastic ham string muscles or even to compression of the sciatic nerve by a spasm of the piri formis muscle. It is most unlikely that any of these explanations are correct and it seems probable that there is a simple mechanical explanation of the association between limitation of and pain on straight leg raising and the presence of a lumbar disc lesion with associated retropulsion of nuclear material.

It has been pointed out already (Chapter III) that the lower lumbar roots in their extrathecal course have a range of movement of between two and eight milli metres. Normally root movement does not commence until the straight leg is raised through an angle of between 30 degrees and 40 degrees (Charnley[4]) In the presence of a nuclear protrusion with root involvement straight leg raising may be nil however and it seems probable that a root displaced by or angulated over a protrusion is more taut than normal and is immediately affected when the leg is raised.

The range of straight leg raising is tested on both legs and it is usual to find that although symptoms are unilateral some limitation is present on both sides As has been pointed out, raising of the sound leg may cause pain referred to the affected leg. Woodhall and Heyes[5] have shown that raising one leg causes the lower lumbar roots on the opposite side to emerge a little from the foramina shift towards the middle line and to a less extent, approach the anterior wall of the spinal canal The first sacral and fifth lumbar roots are most affected by this movement and it is easy to appreciate how in the presence of a paracaudal protru sion this shift might cause a rise in root tension (Fig. 38).

There are a number of tests of a similar nature and based on the same mechanical principles as the straight leg raising test.

The simplest of these the ankle dorsiflexion test, would appear to prove con clusively that root tension is the phenomenon underlying the pain and limitation

[4] Charnley John (1951) Orthopaedic signs in the diagnosis of disc protrusion. *Lancet* cclx, 186-192.
Woodhall, B., & Heyes, G J (1950) The well-leg raising test of Fajersztajn in the diagnosis of ruptured lumbar intervertebral disc. *J Bone Jt Surg* 432-A4 786-792.

of movement associated with this group of tests. The straight leg with the ankle in full plantar flexion is raised to the full limit of the patient's tolerance. The leg

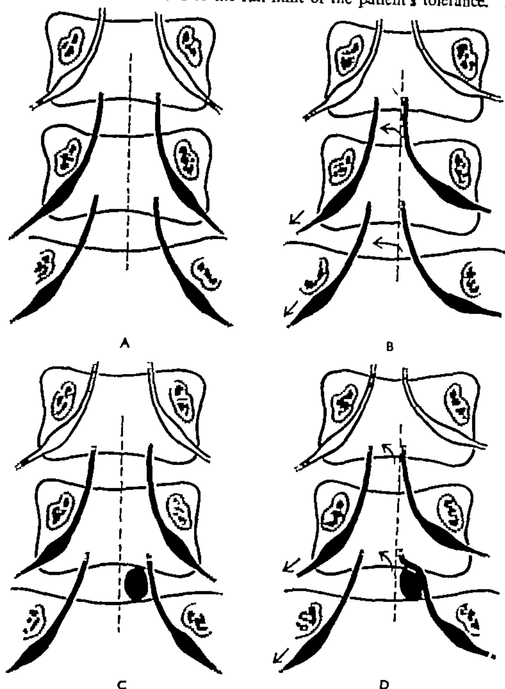


Fig 38

The effects of straight-leg raising on the unaffected side

When the leg on one side is raised the lower roots on the opposite side emerge from the foramina and move towards the mid-line (A and B) In the presence of a paracaudal protrusion this movement may bring a root into contact with the nuclear tumour thus causing a rise in root tension (C and D)

is then lowered an inch or two until the patient is again comfortable. When this point is reached the ankle is strongly dorsiflexed and this movement is associated

with the reappearance of pain Dorsiflexion of the ankle alone cannot be associated with any sacro-iliac or lumbo-sacral movement or with stretching of a spastic piriformis or hamstrings. It is however associated with a stretching of the sciatic nerve through its posterior tibial branch

When there is very severe root irritation the patient holds the affected limb in the position of maximum relaxation of the sciatic nerve that is with the knee and hip flexed and the ankle in plantar flexion Occasionally straight leg raising is entirely lost and full extension of the knee and hip followed by dorsiflexion of the ankle is enough to produce severe pain

The Lasègue test is a modification of the straight leg raising test With the patient supine the leg is raised by flexing both the hip and knee When the hip has been flexed to 90 degrees the knee is slowly extended Normally the knee can be fully extended with the hip in this position but in the presence of root irritation extension of the knee is limited and severe pain occurs at the extreme of this movement. This test is simply a modification of the straight leg raising test and has the disadvantage that as two angles are involved the findings are more difficult to record accurately

A further elaboration of these tests is produced by raising the thecal and root tension by flexion of the cervical spine. When the straight leg is raised to just short of the point of tolerance flexion of the cervical spine raises the root tension and produces severe pain

The range of straight leg raising of both legs together may be tested. It is usually found that the legs may be raised together through an angle greater than that through which the affected leg can be raised but less than that through which the unaffected leg can be raised This apparent increase in straight leg raising on the affected side when both legs are raised together is probably associated with the pelvic tilting which takes place on this movement.

MUSCLE WASTING AND WEAKNESS

When a lumbar disc lesion involves a root any disturbance of the function of the motor fibres of the root causes some loss of bulk and power in the muscles which it supplies

Broadly speaking gross muscle wasting or weakness is a late sign in the ordinary disc lesion. This is not an invariable rule however and occasionally marked weakness followed quickly by muscle wasting, may be a presenting symptom of root involvement. In these particular patients sciatic pain is often either slight or absent and it is the author s opinion that this particular onset is associated with actual compression of the root in its extrathecal course. Three factors tend to produce such a compression retropulsion of a large amount of nuclear material a direct relationship between the site of the retropulsion and the root in its extra thecal course and a small trefoil neural canal (Fig. 33). When a suitable combina tion of these factors exists retropulsion of nuclear material may be associated immediately with severe root compression and marked weakness or even complete

paralysis of the muscles or muscle groups which derive their main nerve supply from the affected root.

Where as is usual root tension or irritation rather than compression is associated with nuclear retropulsion the sequence of events is different. The motor fibres of the root appear to be less affected than the sensory fibres and muscle weakness or wasting is relatively less severe than pain or sensory disturbance. Gross and easily detected muscle wasting is a late sign as is weakness sufficiently severe to be detected by the patient. Nonetheless slight weakness of the affected muscle groups with perhaps a little loss of muscle bulk is generally present even in the early stages although these findings are often overlooked because they are difficult to detect and can only be found on careful clinical examination.

Muscle wasting should be sought in three areas in the buttocks in the thigh *and in the calf* *The buttocks should be examined* with the patient standing erect. In this posture when the gluteal muscles are contracted it is often possible to observe minor degrees of difference between the two sides. The examiner must rely on visual impressions, however as there is no really satisfactory method of measurement

The muscle bulk of the thigh is measured with the patient lying supine and the muscles relaxed The circumference of the thigh is measured at varying distances above the upper pole of the patella and the findings are compared with similar measurements on the opposite leg. In this way variations of a quarter of an inch or less can be detected.

The calf is measured in the same way the circumference being recorded either at the level at which it is greatest or at a fixed distance below the tibial tuberosity and compared with the calf on the unaffected side.

Muscle power is tested in relation to movement of the hip knee and ankle joint. The force with which the various joint movements can be carried out is estimated by the examiner and it is not necessary to use the rather complicated and cumbersome arrangement *of slings and pulleys necessary to compute these* forces in pounds of pressure or other units.

Movements of the hip are tested first. The patient lies supine and first one and then the other hip is flexed this movement being resisted by the examiner who grasps the leg in the region of the knee. The power of adduction and abduction is then similarly tested against resistance and it is usually possible by these means to detect any marked loss of power in one leg.

The power of knee movement is next tested Flexion and extension are carried out against resistance by the examiner and any loss of power in the quadriceps or the hamstring muscle groups on one side is noted

Movements of the ankles and toes are then investigated This is most valuable and important as positive *findings in relation to the power of these movements* enable the examiner to differentiate between lesions involving the fifth lumbar and first sacral roots the two roots which are most commonly affected in lower lumbar disc lesions. Dorsiflexion and plantar flexion of the ankle are tested first and the power of each of these movements is estimated in two ways. Firstly

the movements are carried out against resistance and if the muscle power is normal the patient with an average physique should be able to dorsiflex or plantarflex the ankle in spite of the maximum resistance which can be offered by the examiner The patient is then instructed to hold the ankle in full dorsiflexion and in full plantar flexion and to maintain these positions while the examiner tries to force the foot downwards or upwards Again provided there is no loss of muscle power the patient of average physique should be able to maintain either of these positions in spite of all the force which the examiner can apply

Finally inversion and eversion of the foot are tested against resistance Since the range is so small it is not easy to detect any abnormality short of gross weakness in regard to these particular movements.

The muscle distribution of the various roots which may be involved in lumbar disc lesions is shown in Table III Since the vast majority of lesions affect the L.4 L.5 or L.5 S 1 discs the roots most often involved are the fifth lumbar and first sacral The fourth lumbar root is occasionally affected and very rarely the second and third roots may be irritated by the uncommon lesions of the upper lumbar discs For the purposes of clinical examination root function has been interpreted in the table in terms of joint movement rather than in terms of distribution to individual muscles or muscle groups

The second lumbar root forms part of the motor supply of the flexors adductors and internal rotators of the hip and as far as the leg is concerned is related to movements of this joint only

The third lumbar root is concerned in both hip and knee movement. Its distribution to the hip is the same as that of the second lumbar root, that is it supplies the flexors adductors and internal rotators and it also forms part of the supply to the quadriceps muscle group and hence is concerned with extension of the knee.

The fourth lumbar root supplies the gluteus medius gluteus minimus quadratus femoris and inferior gemellus muscles in the buttock through the superior gluteal nerve and the nerve to the inferior gemellus and quadratus femoris. It is concerned in extension external rotation and abduction of the hip joint, in extension of the knee joint, in dorsiflexion of the ankle joint and of the toes and in inversion of the foot. From the point of view of motor power irritation of the fourth lumbar root is most likely to be confused with irritation of the fifth lumbar root. Lesions of both roots may be associated with wasting in the buttock loss of power of extension external rotation and abduction of the hip and of dorsiflexion of the ankle and toes Whereas the fourth root is concerned with extension of the knee and inversion of the foot however the fifth root supplies muscle groups which perform the exact opposite of these movements that is, this latter root is concerned with flexion of the knee and eversion of the foot

The fifth lumbar root has a wide distribution to all the muscles of the buttock through both the superior and inferior gluteal nerves the nerve to the piriformis and superior gemellus and the nerve to the quadratus femoris and inferior gemellus. It is also concerned with extension external rotation and abduction of the hip flexion of the knee dorsiflexion of the ankle and toes and eversion of the foot.

TABLE III

Root	*Buttock*	*Hip*	*Knee*	*Ankle and Toes*	*Foot*
2nd Lumbar	Nil.	Flexion. Internal rotation. Adduction.	Nil.	Nil.	Nil.
3rd Lumbar	Nil.	Flexion Internal rotation Adduction	Extension.	Nil	Nil.
4th Lumbar	Supplies gluteus medius and minimus (superior gluteal nerve). Quadratus femoris and inferior gemellus (nerve to these muscles).	Extension. External rotation. Abduction	Extension.	Dorsiflexion of ankle and toes.	Inverts foot.
5th Lumbar	Supplies gluteus medius and minimus (superior gluteal nerve). Quadratus femoris and inferior gemellus (nerve to these muscles) and gluteus maximus (inferior gluteal nerve) piriformis and superior gemellus (nerve to these muscles).	Extension. External rotation Abduction	Flexion.	Dorsiflexion of ankle and toes.	Everts foot.
1st Sacral	Supplies gluteus medius and minimus (superior gluteal nerve). Quadratus femoris and inferior gemellus (nerve to these muscles) and gluteus maximus (superior gluteal nerve) piriformis and superior gemellus (nerve to these muscles).	Nil.	Flexion.	Plantar flexion of ankle and toes.	Everts foot.

It is necessary to distinguish between involvement of this root and involvement of the fourth lumbar or much more commonly the first sacral roots The difference between the fourth and fifth lumbar root distributions have been discussed already in the previous paragraph The fifth lumbar and first sacral roots both have a wide distribution to the buttock and are both concerned in flexion of the knee and eversion of the foot The first sacral root has however no effect on hip movement (this is probably not strictly accurate in the anatomical sense but is sound from the clinical point of view) and is concerned with plantar flexion of the ankle and toes as opposed to dorsiflexion as is the case with the fifth lumbar root This latter point is the key to the differentiation between the two roots and for this reason estimation of power of ankle and toe movement is of vital clinical importance

SENSORY CHANGES IN LUMBAR DISC LESIONS

When a root is involved in a lumbar disc lesion abnormalities of sensation may occur in the area of skin that is in the dermatome which it supplies. These can be detected on clinical examination and if the various dermatomes could be charted accurately and were constant in all patients it would be a comparatively simple matter to localise the level of a disc lesion when sensory changes were present.

Unfortunately however it seems quite impossible to produce a chart of the various dermatomes which is uniformly reliable. Many and various attempts have been made to investigate the exact location and extent of the dermatomes in the lower extremity in man and results in these investigations are strikingly dissimilar

The first attempts to produce reliable dermatome charts were made by Sherrington in 1893[6] and 1898[7] Further work on this problem was carried out and the results published by Dejerine[8] in 1914 Head[9] in 1920 Foerster[10] in 1935 Keegan[11] in 1943 Keegan and Garrett[12] in 1948 and many others Among these many investigations the work of Foerster appears outstanding and is probably the most widely accepted In general it seems to be agreed that there is considerable overlap between adjacent dermatomes except when these are separated by the axial lines. This overlap particularly affects the fourth and fifth lumbar and the first sacral dermatomes which are, of course, those most commonly affected in lumbar disc lesions. It also seems probable that there must be considerable variation in the dermatome distribution from individual to individual.

[6] Sherrington, C. S. (1893) Experiments in examination of the peripheral distribution of the fibres of the posterior roots of some spinal nerves. *Phil Trans B* **184**, 641

[7] Sherrington, C. S. (1898) Experiments in examination of the peripheral distribution of the fibres of the posterior roots of some spinal nerves. *Phil Trans. B* **190** 45

[8] Dejerine J J (1914) *Semenologie des affections de système nerveux* Paris, Masson et Cie.

[9] Head, Henry (1920) *Studies in Neurology* London, Oxford University Press.

[10] Foerster O (1933) The dermatomes in man *Brain* **56**, 1 39

[11] Keegan, J J (1943) Dermatome hypalgesia associated with herniation of intervertebral disc. *Arch Neurol Psychiat* **50** 67-83

[12] Keegan, J J., & Garrett, F (1948) The segmental distribution of the cutaneous nerves in the limbs of man *Anat Rec.*, **65**, 273

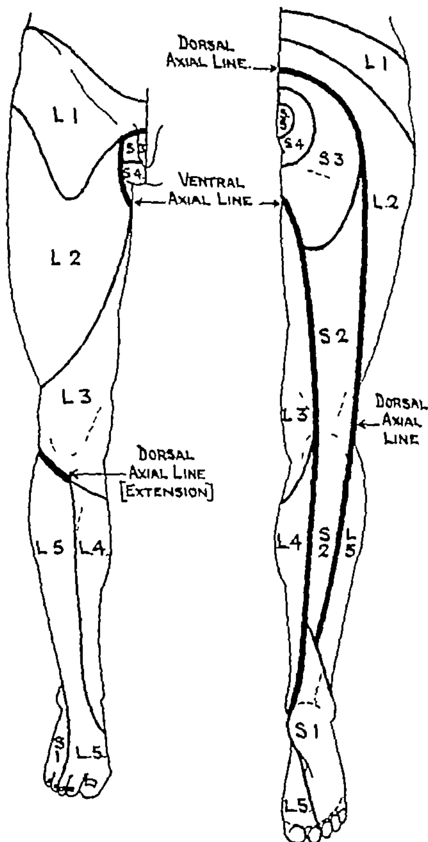


FIG. 39
Dermatome chart
(Reproduced from Aids to the Investigation of Peripheral Nerve Injuries M.R.C. Memorandum No. 7 by permission of the Controller Her Majesty's Stationery Office)

Because of the possibility of wide overlap and of considerable variation it is probable that even the most accurate plotting of the areas of sensory change cannot necessarily supply irrefutable evidence of the level of a lumbar disc lesion and these findings must be considered in conjunction with the sites of referred pain and with the findings in regard to the impairment of motor function

It is the author s custom to test sensation in two ways The patient is tested for light touch with a piece of cotton wool and also with the sharp and blunt end of a pin The areas in which there is any abnormality or loss of discrimination are mapped out and an effort is made to identify the dermatome or dermatomes involved A simple dermatome chart is shown in Fig. 39 but the possibility of overlap or individual variation must always be borne in mind

REFLEX CHANGES

Disturbance of root function by pressure or tension may be associated with alteration in the normal tendon stretch reflexes at the knee and ankle. Reflex changes may be of considerable value in the localisation of the level of root disturbance.

The roots concerned in the knee jerk are the third and fourth lumbar and gross disturbance in the function of either of these may be associated with diminution of the normal jerk This reflex is almost never lost completely however in any type of lumbar disc lesion In the lesions at the usual site that is at the L.4 L.5 and L.5 S 1 disc level the knee jerk is not affected

The roots involved in the ankle jerk are the first and second sacral Disturbance of function of the first sacral root, such as commonly occurs in lesions of the L.5 S 1 disc, is associated with diminution or even with complete loss of the ankle jerk. Once this reflex has been lost recovery is very slow even if the affected root is completely freed and relieved of all pressure by operation Even in the most favourable circumstances a lost ankle jerk cannot usually be expected to recover in less than a year

Alteration in the ankle jerk is a most useful sign in that it enables a clear distinction to be made between involvement of the fifth lumbar and of the first sacral root, the two roots which are most commonly affected in lumbar disc lesions.

RADIATED PAIN ON PERCUSSION OR PRESSURE

In the acute stages of root irritation a sciatic radiation of pain is often produced by firm pressure on or percussion of the lower lumbar spine.

With the patient standing either erect or in slight forward flexion firm pressure is applied to the lower lumbar region on the affected side with the examiner s thumb In certain cases this pressure is associated with radiated pain felt in the leg.

A similar type of pain may sometimes be produced by percussion of the lower lumbar region The patient stands with the lumbar spine in moderate forward flexion and the examiner percusses the lumbo-sacral region firmly with the closed fist or with a padded mallet The test is positive when percussion produces pain

radiating to the leg. The presence of radiated pain on percussion or pressure is a valuable confirmatory sign of the presence of a disc lesion with root involvement and further indicates that the affected root is in a state of fairly acute irritation. This sign is only present, however in between 10 and 20 per cent. of all patients in whom lumbar disc lesions are associated with sciatic pain and often only occurs *in these patients* during the stage of acute root irritation. Its absence therefore does not in any way exclude the possibility of a disc lesion with root involvement.

JUGULAR COMPRESSION TEST

When both internal jugular veins are compressed for a few seconds a rise in intrathecal tension is produced This rise in tension is associated with some distension of the spinal meninges and consequent slight stretching of the nerve roots of the cauda equina in their extrathecal course. If a root is compressed or stretched by or adherent to retropulsed nuclear material this slight increase in its already abnormally high tension is sufficient to produce radiated pain of monoradicular distribution (Viets[13]).

Jugular compression may be produced by digital pressure or by the use of a sphygmomanometer cuff (Aird and Naffziger[14]) The test is said to be more likely to be positive if it is carried out with the patient sitting or standing rather than in a supine position, and the pain usually occurs within the first half minute of jugular compression

This test is usually only positive in those patients who have severe radiating pain on coughing or sneezing. In the author's opinion it is neither particularly sensitive nor of any great diagnostic value although when positive it probably does indicate a marked degree of root irritation

CONGENITAL ABNORMALITIES AND SITE OF LESION

As has been pointed out *the site of a disc lesion is determined mainly by the* clinical pattern of root involvement. The signs and symptoms associated with *the various root pictures have been discussed in the previous paragraphs on the* assumption that the patient has a normal lumbar plexus and five mobile vertebrae in the lumbar region. Such is by no means always the case. No reliable statistics exist regarding the incidence of a pre or post fixed lumbar plexus but in the opinion of the author such abnormalities are relatively common as are variations *in the number of mobile lumbar vertebrae*

When such abnormalities exist they must be taken into account if the level of a disc lesion is to be diagnosed accurately From the practical point of view this is of most importance in relation to the operative exposure of a disc lesion and the effects of these abnormalities are discussed in detail in the chapters dealing *with operative treatment.*

[13] Viets, H R. (1928) Two new signs suggestive of cauda equina tumor *New Engl J Med.*, 198, 671-674

[14] Aird, R. B. & Naffziger J C (1940) Prolonged jugular compression—new diagnostic test of neurological value *Proc Amer Neurol Ass* 66, 45-49

CHAPTER IX

THE CLINICAL PICTURE IN LUMBAR DISC LESIONS

(Continued)

ANCILLARY INVESTIGATIONS

RADIOGRAPHY OF LUMBAR SPINE AND LUMBO-SACRAL REGION

THE chief value of radiographs of the lumbar spine is that they may show or exclude other pathological conditions which might simulate lesions of the lumbar intervertebral discs The radiographic findings in such conditions will be fully discussed in the section dealing with differential diagnosis and the value of comprehensive and clear radiographs cannot from this point of view be over estimated

There are, however certain radiographic changes which are associated with and to some extent, are diagnostic of disc lesions Unfortunately these changes may be misleading in a number of respects, and in the author s view they are more to be regarded as confirmatory rather than primary evidence of the presence of a disc lesion

INTERVERTEBRAL NARROWING

Narrowing of the space between the vertebral bodies follows posterior displacement or surgical removal of part or all of the nucleus pulposus (Plate 5) and may also occur in a lesser degree in association with degenerative changes in the nucleus without nuclear displacement.

In some instances narrowing of the intervertebral space can be detected radiologically fairly soon after displacement or removal of the nucleus pulposus. Gillespie,[1] for example reported that in some patients a steep decrease in the intervertebral space becomes evident four weeks after operative removal of the nucleus In others, however intervertebral narrowing is delayed and may not become obvious for months or even years after the onset of symptoms (Plate 6)

In the author's opinion intervertebral narrowing is not a strictly comparable phenomenon in patients treated surgically and in those treated conservatively or left untreated. In the presence of a disc lesion diminution of the space between the vertebral bodies is variable, depending not so much on actual nuclear retro pulsion as on the degree and extent of pathological change in the disc as a whole. After adequate surgical removal of the nucleus, on the other hand diminution of the intervertebral space is inevitable It probably begins immediately after opera

[1] Gillespie, H W (1947) Further observations on radiological diagnosis of lumbar intervertebral disc lesions. *Brit J Radiol.*, 20 37



PLATE 5

Intervertebral narrowing due to disc lesion

This patient had a history of intermittent low back pain for some four years followed by severe pain and intractable sciatica of first sacral root distribution for seven months. The plate shows moderate narrowing of the L.5 S.1 inter space and at operation a few days later degeneration of this disc with advanced nuclear sequestration and a large posterior nuclear protrusion was found.



PLATE 6

Disc lesion without intervertebral narrowing

This patient had a history of attacks of low back pain and sciatica over a period of three years, culminating in a severe attack which had persisted unchanged for five months. The plate shows no real intervertebral narrowing, yet at operation a few days later degeneration of the L.4 L.5 disc with nuclear sequestration and a posterior nuclear protrusion was found.

tion becomes obvious in a few weeks and, in favourable cases, reaches its maximum in about a year thereafter remaining constant (Plate 7)

While intervertebral narrowing is probably the most valuable radiographic *sign of the presence of a disc lesion* it cannot by any means be regarded as a constant or uniform finding For example, in a series of 160 patients reported by Gillespie [2] narrowing was only present in 31 2 per cent. of patients.

Further narrowing of the intervertebral space does not necessarily indicate a disc lesion Apparent narrowing may be produced by inaccurate centring as the radiographs are taken True narrowing occurs in old age and in association with certain other lesions of the spine. For example, narrowing of a disc space is one *of the early signs of tuberculosis* and may occur before other changes are visible.

INTERVERTEBRAL ARTHRITIS

Arthritic changes around the intervertebral space are a late complication of disorganisation of an intervertebral disc. These are of a *degenerative nature and* are shown by marginal lipping of the vertebral bodies and sclerosis of the body surfaces in contact with the diseased disc (Plate 2) The presence of such arthritic changes indicates that the loss of intervertebral disc space is of long standing.

Not uncommonly such changes are found in association with a recent history of low back pain and sciatica, and very frequently in these circumstances a recent disc lesion is present at another level than that at which these changes exist.

POSTERIOR SHIFT OF VERTEBRAL BODY

Apparent posterior displacement of the vertebral body of the fifth lumbar vertebra is commonly observed in association with narrowing of the lumbo-sacral intervertebral space (Plates 7 and 8) This appearance is partly accounted for by the fact that the inferior surface of the fifth lumbar body has a greater antero-posterior diameter than the upper surface of the first sacral vertebra so that when these bony surfaces are *brought into apposition the fifth lumbar vertebra projects* backwards in relation to the sacrum. Fletcher [3] however has recently pointed out that some true posterior displacement of the fifth lumbar vertebra may occur when the lumbo-sacral interspace is lost, and he attributes some clinical significance to this fact Such displacement would appear to depend on the plane of the posterior articular facets of the sacrum. If these facets are *vertical narrowing could occur* without displacement If on the other hand the facets are slightly oblique in *relation to the vertical* plane, narrowing would be associated with some slight posterior shift of the fifth lumbar vertebra (Fig. 40)

[2] *Gillespie H W (1946)* Radiological diagnosis of lumbar intervertebral disc lesions report on 160 cases. *Brit J Radiol* 19 420-429

[3] Fletcher G H (1947) Backward displacement of fifth lumbar vertebra in degenerative disc disease The significance of the difference in antero-posterior diameters of the fifth lumbar and first sacral vertebrae *J Bone Jt Surg* 29 1019

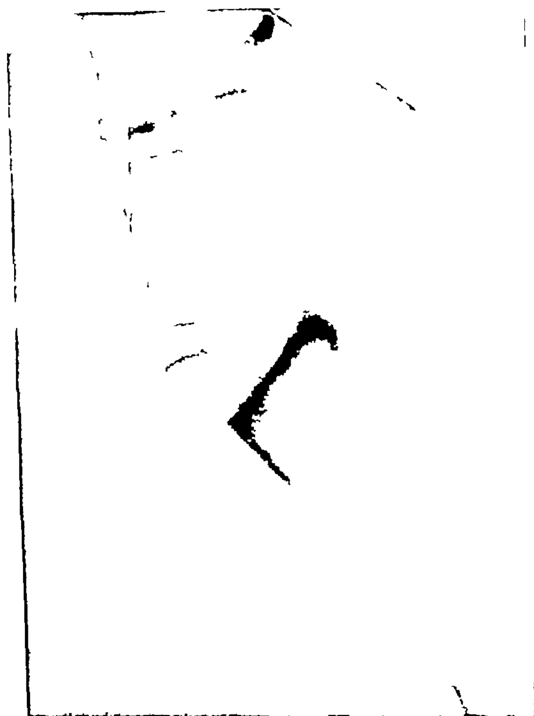


PLATE 7

Intervertebral narrowing following operation

Radiograph taken two years after removal of the nuclei of the L.4 L.5 and L.5 S.1 discs for a double disc lesion. The degree of narrowing is the same as that shown on plates taken a year previously (Note the apparent posterior displacement of the fifth lumbar vertebra.)



PLATE 8
Apparent posterior displacement of the fifth lumbar verebral body in relation to the sacrum occurring in association with narrowing of the L.5 S.1 inter vertebral joint.

DEVELOPMENTAL ABNORMALITIES

The presence of various developmental abnormalities is a common occurrence in patients suffering from lesions of the lower lumbar discs It is doubtful whether the majority of abnormalities have any clinical significance, although most observers have the impression that their incidence is higher in patients with disc lesions than in people whose lumbo-sacral spines are functionally normal

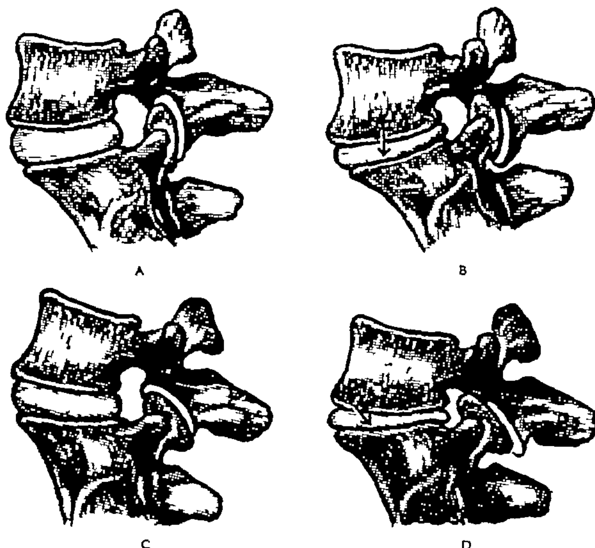


Fig. 40

Relation between planes of posterior articular facets and intervertebral narrowing

When the planes of the posterior articular facets are comparatively vertical (A) intervertebral narrowing is not associated with any great posterior shift of the fifth lumbar body in relation to the sacrum (B) When the planes are oblique, however (C), narrowing of the L5 S.1 space is accompanied by some backward displacement of the fifth lumbar body (D)

The most important groups of these congenital defects are spondylolysis or spondylolisthesis, failures of posterior fusion producing a spina bifida at various levels or abnormalities in the number of mobile or partially mobile vertebrae in the lumbar region.

These latter abnormalities are particularly significant in that they affect the technique of operative exposure of the lower two lumbar discs, and their significance in this respect will be fully discussed later It should be noted however that the presence of the partially sacralised fifth lumbar vertebra or partially lumbarised first sacral vertebra is associated with a narrowed and abnormal interspace between this vertebra and the solid sacrum, and that this abnormal interspace may be the site of arthritic changes In these circumstances, the presence of a narrowed interspace is a developmental anomaly and does not indicate a disc lesion at this level (Plate 9)

MYELOGRAPHY

Myelography is a most valuable measure in the diagnosis and localisation of spinal tumours and of certain other conditions in which the spinal theca is compressed and encroached upon. The value of myelography in the diagnosis and localisation of lesions of the lower lumbar discs is, however doubtful

For some years after the description of these lesions myelography was considered an indispensable adjunct in their diagnosis, and many clinicians held that a positive myelograph was necessary before the presence of a disc lesion could be accepted More recently however myelography has fallen into considerable disrepute in many centres and its value has been questioned

Using an opaque medium it is possible to demonstrate a filling defect when the spinal theca is compressed by any extrathecal object and the defect thus caused varies with and is an indication of the size and position of the compressing object. As applied to the diagnosis of disc lesions, however the method of examination is open to various criticisms.

Myelography is, of course of no value in the diagnosis of disc lesions in the stage before annular rupture and nuclear retropulsion Further even when this stage has been reached the tumour caused by retropulsion of nuclear material is essentially small and produces its characteristic symptoms not by encroaching on the theca but by involving the taut extrathecal roots. It is only in exceptional circumstances that displaced nuclear material deeply compresses the spinal theca Indeed, the usual site of a disc protrusion is on the antero-lateral aspect of the theca, and some protrusions are so lateral that they are not in direct contact with the theca at all

A small and flattened protrusion, even if in contact with the theca may not produce an obvious defect but may cause a marked rise in tension in the relatively taut extrathecal root with which it is in direct contact This type of protrusion may therefore be associated with marked symptoms of root irritation without indenting the theca to a detectable extent

From time to time fresh claims are made regarding the value of myelography For example, as a result of their observation in 95 patients with disc lesions subsequently proved at operation Falconer McGeorge and Begg[1] concluded that

[1] Falconer M A McGeorge M & Begg, A. C (1948) Observations on the cause and mechanism of symptom-production in sciatica and low back pain *J Neurol., Neurosurg Psychiat* 11 13-26



PLATE 9

Transitional vertebra associated with lumbar disc lesion

In this patient a transitional first sacral vertebra was associated with a rudimentary intervertebral space between the vertebral body and the solid sacrum (A) This rudimentary space is the site of degenerative changes. A true disc lesion did exist at the L.4 L.5 interspace (B) and at operation a few days after this plate was taken a degenerate fragmented nucleus with a large posterior nuclear retropulsion was found at this level

myelography could demonstrate disc lesions in most cases, and when it was *positive it was reliable,* although they did admit that a negative finding did not exclude a disc lesion In fact, in 9 out of the 95 cases (9 5 per cent.) findings were obscured by artifacts due to faulty technique In the remaining 86 cases radiographic appearances were deemed pathological in 76 but in two subsequent operations showed lesions at a level other than that indicated by the myelographs. In the ten patients deemed normal operation revealed lesions. In other words, *in only 74 out of 95 patients (78 per cent.)* with proved disc lesions did myelography show the lesion with accuracy an error greater than one in five

Ford and Key[3] who also consider myelography a valuable aid to diagnosis, *found in a series of 206 patients operated on after myelography major discrepancies* between the myelogram and the surgical findings in 19·4 per cent. of cases, and minor discrepancies in a further 8 3 per cent. of cases, a total error of 27 7 per cent., *or greater than one in four*

The author s view which is probably typical of the view held in most clinics in this country and in many clinics in America is that a myelogram is an uncertain *and unreliable method of demonstrating the presence of a lesion of a lower lumbar* disc and that many such lesions cannot possiblv be detected by myelography

Myelograms have, moreover certain disadvantages and dangers. The procedure *is extremely unpleasant for the patient and is cumbersome and time-consuming.* The introduction of any opaque medium into the spinal theca is not without its immediate dangers and there is always the possibility of late complications. In the past there has been a great deal of unjustifiable optimism about the harmlessness of the various preparations used. In fact, as Hurteau, Baird and Sinclair[4] have shown, both clinical and experimental evidence suggests that the iodised oils in common use may provoke a severe reaction in the subarachnoid space

The author considers that myelography should be reserved for those patients in whom the presence of a spinal tumour is suspected and that it is contra indicated in all other patients. In particular this investigation should not be used in patients with low back symptoms when the presence of a disc lesion is doubtful In these circumstances a negative myelograph is of no significance whatever In such cases the diagnosis can usually be made by observation over a period of months and by the response of the symptoms to conservative treatment

NUCLEOGRAPHY

Examination of the nucleus pulposus by contrast radiography is made possible by injection of a radio-opaque watery solution of iodine directly into the nuclei themselves

Different nuclear patterns of varying clinical significance have been described (Erlacher[7]) and the posterior escape of opaque solution is said to indicate nuclear retropulsion.

Ford, L. T., & Key J A. (1950) An evaluation of myelography in the diagnosis of intervertebral disc lesions in the low back. *J Bone Jt Surg* 32A 2.
Hurteau, E. F., Baird, W C., & Sinclair E. (1954) Arachnoiditis following the use of Iodised Oil *J Bone Jt Surg.*, 36A, 393–400.
[7] Erlacher P B (195_) Nucleography *J Bone Jt Surg* 34B, 204 –10

Whatever the diagnostic value of this investigation may be it must be obvious that blind puncture of a lumbar intervertebral disc is, to put it at its lowest a hazardous procedure.

Theoretically the needle is inserted on the lateral side of the theca and punctures the disc medially to the root which crosses it in its extrathecal course However simple it may be to represent such a course in diagrammatic form in practice various difficulties arise.

The theca occupies the whole of the spinal canal and however lateral the point of entry may be, is often punctured or traversed by the needle The extrathecal venous plexus, particularly the anterior branches may be punctured or torn while the extrathecal root in relation to the disc is also in grave danger Even a normal root may be damaged while a root adherent to and flattened over a nuclear protrusion can hardly escape if annular puncture is attempted on this side

There is also the question of damage to the disc itself Many records exist of disc lesions developing after accidental annular puncture either during the administration of a spinal anaesthetic or in the course of a diagnostic lumbar puncture. The injection of fluid under high pressure into the nucleus must cause damage by breaking up the fibrous mesh which is an essential part of its structure Finally there is no reason to suppose that iodine is less likely to cause local reaction in the nucleus than elsewhere in the body

Erlacher* minimises these dangers but qualifies this by saying In any case, nucleography should be restricted to cases in which early operation is contemplated, but in which diagnosis and localisation cannot be made with accuracy It is difficult to see why early operation should be contemplated in these circumstances but perhaps nucleography makes certain that subsequent operative removal of the nucleus so investigated is desirable.

In the opinion of the author the risk of damage to the contents of the spinal canal and to the disc itself associated with nucleography using an opaque medium injected directly into the disc are such that this investigation is unjustifiable

LUMBAR PUNCTURE

Lumbar puncture and the examination of a specimen of cerebrospinal fluid is not an investigation which has great value in the routine diagnosis of lesions of the lower lumbar discs In certain circumstances, notably when a tumour is suspected the investigation may be an important step in the differential diagnosis, but apart from this there are with one possible exception no abnormal findings on lumbar puncture in the presence of a typical disc lesion.

The exception is the protein content in the cerebrospinal fluid The protein is, of course, raised when any condition produces mechanical blocking of the subarachnoid space with isolation of cerebrospinal fluid caudal to the lesion When this fluid is drained by lumbar puncture its protein content is much greater than the normal 20 to 40 mg. per 100 ccs If a disc lesion produces a complete block

* Erlacher P B (1952) Nucleography *J Bone Jt Surg.*, 34B, 204 210

or even a substantial degree of blocking some rise in the protein content of the cerebrospinal fluid distal to this block is usual In the case of a lesion of the L.5 S 1 disc it is of course, impossible to do a lumbar puncture in the ordinary way caudal to the lesion and in the case of an L.4 L.5 disc the theca must be punctured in the L.5 S 1 interspace if the fluid most affected is to be examined It is unusual, however for a disc lesion to produce complete blocking, and although an obstruction so produced may be sufficient to cause stagnation of cerebrospinal fluid distal to the lesion even if this stagnation is associated with a rise in protein content there is some interchange of fluid past the level of the obstruction. This accounts for the comparatively small rise in protein content which is usual in cerebrospinal fluid drawn from above the level of a partial obstruction caused by a lesion of the lower lumbar discs This slight rise in protein content is, however inconstant and of limited value in diagnosis or differential diagnosis

The investigation of lumbar puncture has many very real dangers and is undertaken far too lightly In particular when a lesion of one of the lower lumbar discs is suspected and a lumbar puncture is carried out at a very low level with the intention of obtaining a specimen of the cerebrospinal fluid from below the level of the disc lesion it is quite possible to damage one of the roots of the cauda equina as they pass over the nuclear protrusion For these reasons and because it has no particular value, lumbar puncture should not be a routine investigation in all patients suspected of disc lesions and should be reserved for those patients in whom symptoms are sufficiently atypical to suggest the possibility of the presence of some form of spinal tumour

CHAPTER X

THE DIFFERENTIAL DIAGNOSIS OF LUMBAR DISC LESIONS

THERE is much unjustifiable pessimism in our present approach to the clinical problems associated with low back pain and sciatica One might imagine that there were, among the possible causes a number of obscure conditions the existence of which we can guess but about whose nature we are quite ignorant, and that because of this group it is impossible in a material proportion of cases to arrive at any diagnosis with certainty Such is not the case, no such conditions exist.

It is true that the various pathological conditions which may cause low back pain form a large and somewhat ill-defined group and that the same applies to those associated with sciatic pain It is possible, however to classify both these groups in a fairly orderly manner and the clinical findings associated with the different conditions are reasonably characteristic.

In considering individually and in detail the conditions which may simulate lumbar disc lesions various difficulties arise. Three groups of disorders must be taken into account those causing low back pain those causing sciatic pain and those common to both groups, that is those causing both low back pain and sciatic pain The latter are the most common source of difficulty in differential diagnosis and their symptoms may resemble those of lumbar disc lesions very closely

This third group is listed in Table IV and the most characteristic features of these conditions are now briefly considered

TABLE IV

CONDITIONS ASSOCIATED WITH LOW BACK PAIN AND SCIATICA

1 *Lumbar Disc Lesions.*
2. Spondylolisthesis.
3 Sacralised transverse process with pseudarthrosis.
4 Developmental narrowing of spinal canal
5 Malformation of lumbar roots and sheaths
6 *Osteoarthritis of lumbar spine.*
7 Intraspinal Tumours.
8 Spondylitis Ankylopoetica
9 Paget s Disease
10 Osteomyelitic Abscess
11 Tuberculous Abscess.

SPONDYLOLISTHESIS

The signs and symptoms associated with this condition may resemble very closely those of a lumbar disc lesion There are however certain significant points of distinction.

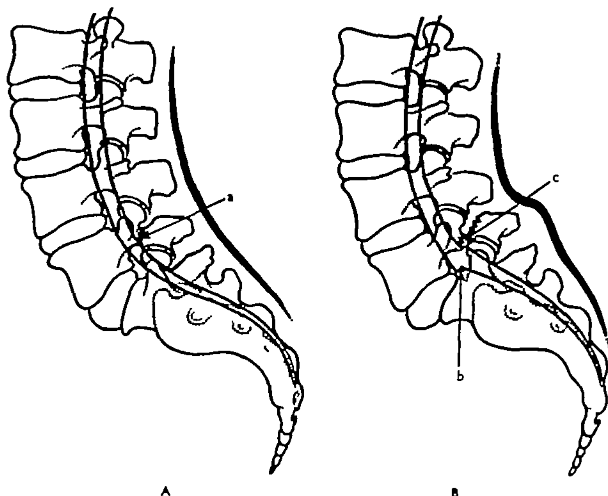


Fig. 41

Mechanism of displacement in spondylolisthesis.

Linear defects (a) exist in the neural arch of one (usually the fifth) lumbar vertebra, passing between the upper and lower articular processes on each side (A) The vertebra affected slips forward carrying with it the spinal column above and leaving its neural arch in normal relationship to the vertebra below (B) Two indentations in the spinal canal are produced, a lower anterior step formed by the upper and posterior edge of the vertebra below (b) and an upper and posterior indentation caused by the anterior shift of the lamina and ligamenta flava of the vertebra above (c).

Mechanism of Symptom Production:

Spondylolisthesis occurs as the result of defects in the neural arch of one vertebra The posterior part of the arch either fails to fuse with or is broken off from the anterior part the line of cleavage passing between the upper and lower articular processes on each side (Fig. 41A) The lower processes are attached to and form part of the loose posterior fragment of the arch while the upper remain attached to the vertebral body by the pedicles. As the result of mechanical pressure

from above, separation takes place at the site of the defect, the vertebral body sliding forward and carrying with it the entire vertebral column above, while the posterior fragment remains in its normal relationship to the vertebral body below. The anterior displacement of the vertebral body both disorganises the joint between it and the body below and produces a "step" in the anterior surface of the vertebral canal at the site of displacement, together with an indentation in the posterior wall of the canal between the laminae of the affected vertebra and the vertebra above (Fig. 41B).

The disorganisation of the joint between the two vertebral bodies and the local stretching of all tissues which follows forward displacement of the upper

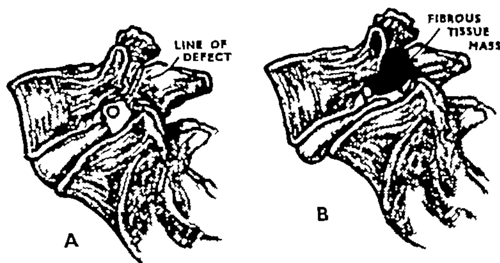


Fig. 42

The defect passes between the upper and lower articular facets (A). When separation occurs this defect becomes surrounded by a mass of fibrous tissue which encroaches on the vertebral foramen and involves the nerve root.

segment of the spine are responsible for symptoms referred to the low back. Later the disorganised joint is the site of arthritic changes which also cause local symptoms.

The symptoms of root irritation are referred to the legs and may be produced in three ways.

The step or ledge in the anterior wall of the vertebral canal produced by the upper and posterior edge of the vertebral body below the anteriorly displaced body is in intimate contact with two roots in their extrathecal course and close to their exit from the theca. When displacement becomes pronounced these roots may be stretched over this ledge and symptoms of root irritation or compression ensue. Since the anterior displacement is often associated with some rotation, the root on one side may be more affected than that on the other; hence symptoms may be unilateral or bilateral.

In addition to this local interference with two roots in their extrathecal course the whole of the cauda equina may be involved when the displacement is sufficient to produce gross distortion of the spinal canal. Where this happens there may



PLATE 10A

Spondylolisthesis in an adult

Spondylolisthesis in an adult showing typical displacement



PLATE 10B
Spondylolisthesis in a child
Spondylolisthesis in a child aged 12 showing typical displacement.

be disturbance of the function of all the roots, both extrathecal and intrathecal, at and below the level of the lesion Sensory motor and reflex changes occur in the legs, and there may be associated bladder and rectal symptoms.

The roots crossing the anterior step in the spinal canal are not the only ones which may be affected by a spondylolisthesis.

The laminar defect becomes surrounded by an ill-defined mass of fibrous tissue in which there are areas of mucoid degeneration. This fibrous mass encroaches upon the vertebral foramen and either presses on or becomes adherent to the nerve root (Fig. 42) Either irritation of or traction on the adherent root may produce sciatic symptoms (Adkins,[1] Gill Manning and White[2])

It should be noted that while a spondylolisthesis may produce root symptoms in the manner just described, the presence of root symptoms in association with this condition may be due to an intervertebral disc lesion. Occasionally spondylolisthesis is complicated by a lesion occurring in the disc immediately above or below the spondylolisthesis This complication is referred to in more detail later

Patient's History

Spondylolisthesis is associated with a history of chronic backache made worse by exertion and relieved by rest. There are, however no severe or acute exacerbations and complete remissions are rare Occasionally sciatica of a monoradicular distribution either unilateral or bilateral is present, and very occasionally there may be weakness sensory disturbance or bladder or rectal symptoms produced by cauda equina pressure.

Clinical Findings

Examination of the low back should always reveal the presence of a spondylolisthesis An increased lumbar lordosis the typical 'dimple and pain or discomfort at extremes of all lumbar movements without gross relative limitation of the range of any are the characteristic findings These findings are not those associated with disc lesions.

If sciatica is present the signs and symptoms are usually those of unilateral or bilateral monoradicular root irritation In those rare patients with cauda equina pressure there are sensory motor and reflex changes in the legs of a degree and distribution determined by the severity of the interference with root function

Radiographic Examination

The presence of a spondylolisthesis is revealed by radiographic examination of the lumbar spine, the findings being obvious and definite (Plates 10A and 10B)

Disc Lesion Associated with Spondylolisthesis:

In the ordinary way it is possible to differentiate between a spondylolisthesis and a lumbar disc lesion on clinical grounds and to confirm the opinion so formed by radiography

[1] Adkins, E W (1955) Spondylolisthesis. *J Bone Jt Surg* 37B, 48-62.
[2] Gill, G G., Manning, J G., & White, H L (1955) Surgical Treatment of Spondylolisthesis without Spine Fusion. *J Bone Jt Surg* 37A 493 518

It is extremely important however to realise that it is by no means uncommon to find *a lumbar disc lesion in association with but at a level other than a* spondylolisthesis The L.4 L.5 disc is affected in an L 5 S 1 spondylolisthesis and the L.5 S 1 disc in association with the uncommon L 4 on L.5 spondylolis thesis In these circumstances the signs of a disc lesion are superimposed on those associated with the spondylolisthesis

Unless this possibility is borne in mind the disc lesion may be overlooked and the patient s symptoms attributed to the spondylolisthesis only This error may have most unfortunate results if the patient is then treated by spinal fusion This procedure successful in the case of an uncomplicated spondylolisthesis with out root irritation in no way relieves symptoms due to root irritation from an associated disc lesion and greatly em barrasses the further surgical treatment of such a lesion

Two findings provide a clue to the presence of a disc lesion in association with a spondylolisthesis

In the lumbar spine the characteristic lordosis and dimple are associated with muscle spasm and limitation of flexion and extension with pain on forcing these movements, lateral flexion and rotation being relatively free. A postural scoliosis *may also be present and this is not pro*duced by a spondylolisthesis alone

In the leg when sciatic pain is produced by root irritation due to an associated disc lesion the root affected is that in contact with the abnormal disc and not that which crosses the ledge formed by the posterior upper border of the vertebral body below the level of the spondylolisthesis (Fig. 43)

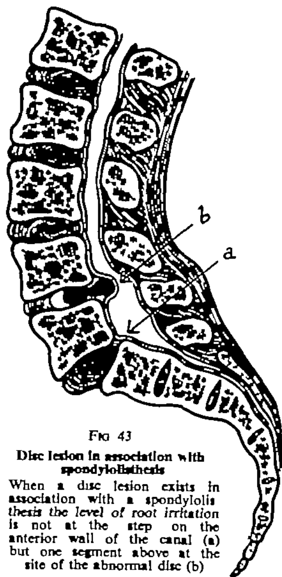


FIG 43

Disc lesion in association with spondylolisthesis

When a disc lesion exists in association with a spondylolis *thesis the level of root irritation* is not at the step on the anterior wall of the canal (a) but one segment above at the site of the abnormal disc (b)

Differential Diagnosis

The clinical findings and the radiological appearance make it possible to *differentiate between an uncomplicated spondylolisthesis* and a lumbar disc lesion. Symptoms of root involvement at a level other than that of the spondylolisthesis suggest the possibility of the presence of an associated abnormality of a lumbar disc.

A

SACRALISED TRANSVERSE PROCESS WITH PSEUDARTHROSIS

Variations in the number of mobile vertebrae in the lumbar region is one of the commonest of developmental anomalies found in the low back. The significance of this abnormality as a cause of low back pain will be discussed later at present it is sufficient to say that it is not of itself associated with pain referred to the legs Such variations may be produced by lumbarisation of the first sacral vertebra or sacralisation of the fifth lumbar vertebra, and quite commonly this process is incomplete The first sacral vertebra may be only partially detached from or the fifth lumbar vertebra partially attached to the pelvis. The most common form of this partly mobile vertebra, the so-called transitional vertebra, is one which has a joint, either normal or rudimentary between its body and the solid sacrum but is in bony contact with or fused to the pelvis through one or both of its transverse processes. When a transverse process from such a vertebra is in contact with but not fused to the sacrum or ilium a pseudarthrosis forms at the point of contact.

Mechanism of Symptom Production

The pseudarthrosis between a transverse process and the pelvis is inevitably if the vertebra concerned is otherwise free the site of some movement. *Since it is not a true* joint it tends to wear badly and arthritic changes occur These changes are associated with pain felt in the low back.

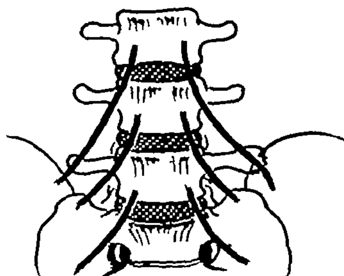


Fig. 44

Root relation to pseudarthrosis formed by sacralised transverse process

A root in its extrathecal course may be in relation to a pseudarthrosis between an *abnormal transverse* process and the sacrum. (Diagrammatic.)

The size and shape of the transverse process varies a great deal, and the exact site of the pseudarthrosis varies accordingly In certain circumstances the fourth or the fifth lumbar *root depending on* whether the transitional vertebra is the fifth lumbar or the first sacral, may after emerging *from the spinal* foramen be in direct contact with the anterior surface of the pseudarthrosis In *these cir*cumstances the root in contact may be involved in the arthritic process with consequent irritation and pain referred to the leg (Fig. 44).

Patient's History

The patient with an arthritic pseudarthrosis of a sacralised transverse process complains of low back pain This pain is localised to the site of the pseudarthrosis and is made worse by exertion and by certain movements.

When root irritation is present the patient complains of pain of monoradicular distribution felt in one leg

Clinical Signs

On examination of the low back the pain is referred fairly accurately to the site of the pseudarthrosis Deep local tenderness is commonly present and there is pain in this area at the extremes of lateral flexion and rotation Some spasm of the lumbar muscles is usual particularly on the affected side.

On examination of the legs there is pain referred accurately to the dermatome of the affected root and the presence of root irritation is shown by limitation of straight leg raising. Sensory motor or reflex changes are not usually present.

Radiological Findings

Radiographs show an abnormal transverse process with an associated pseudarthrosis (Plate 11) and often there is narrowing of the joint between the transitional vertebra and the solid sacrum Such narrowing does not necessarily indicate any disc abnormality since the joint may be partially rudimentary with a disc which is less thick than normal.

Differential Diagnosis

The sacralised transverse process with an arthritic pseudarthrosis is an un common enough condition and even when it is present a particular anatomical arrangement is necessary before it can be associated with root irritation It should also be remembered that skeletal anomalies in the lumbar region are commonly found in association with disc lesions

The presence of the sacralised transverse process and arthritic pseudarthrosis is shown by radiography The difficulty is to decide whether this condition or an associated disc lesion is responsible for the patient's symptoms.

The level of the root responsible for symptoms referred to the leg often provides a clue to the differential diagnosis. If the transverse process forming the pseudarthrosis arises from the fifth lumbar vertebra the only root which can be involved in arthritic changes is the fourth lumbar If a lumbarised first sacral vertebra forms the false joint the fifth lumbar root is the only one which may be involved (Fig. 45) The first sacral root can never be in anatomical contact with such a pseudarthrosis. If the root symptoms do not correspond in level to this arrangement the presence of an arthritic pseudarthrosis is a coincidental finding and is not responsible for the patient's symptoms.

Further the clinical findings in the low back in the presence of an arthritic pseudarthrosis are not those of a disc lesion Flattening of the normal lumbar lordosis is not present and lateral flexion and rotation are more limited and painful than flexion and extension Pain and deep tenderness are also more localised than is the case with a disc lesion

SACRALISED TRANSVERSE PROCESS WITH PSEUDARTHROSIS

Variations in the number of mobile vertebrae in the lumbar region is one of the commonest of developmental anomalies found in the low back. The significance of this abnormality as a cause of low back pain will be discussed later at present it is sufficient to say that it is not of itself associated with pain referred to the legs. Such variations may be produced by lumbarisation of the first sacral vertebra or sacralisation of the fifth lumbar vertebra and quite commonly this process is incomplete The first sacral vertebra may be only partially detached from or the fifth lumbar vertebra partially attached to the pelvis. The most common form of this partly mobile vertebra the so-called transitional vertebra, is one which has a joint, either normal or rudimentary between its body and the solid sacrum but is in bony contact with or fused to the pelvis through one or both of its transverse processes When a transverse process from such a vertebra is in contact with but not fused to the sacrum or ilium a pseudarthrosis forms at the point of contact

Mechanism of Symptom Production

The pseudarthrosis between a transverse process and the pelvis is inevitably if the vertebra concerned is otherwise free, the site of some movement. Since it is not a true joint it tends to wear badly and arthritic changes occur These changes are associated with pain felt in the low back.

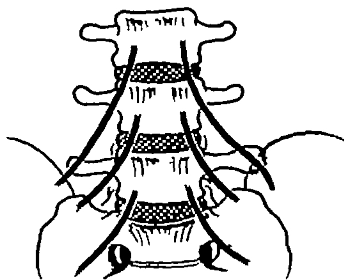


FIG. 44

Root relation to pseudarthrosis formed by sacralised transverse process

A root in its extrathecal course may be in relation to a pseudarthrosis between an abnormal transverse process and the sacrum (Diagrammatic.)

The size and shape of the transverse process varies a great deal and the exact site of the pseudarthrosis varies accordingly In certain circumstances the fourth or the fifth lumbar root, depending on whether the transitional vertebra is the fifth lumbar or the first sacral, may after emerging from the spinal foramen be in direct contact with the anterior surface of the pseudarthrosis. In these circumstances the root in contact may be involved in the arthritic process with consequent irritation and pain referred to the leg (Fig. 44).

Patient's History

The patient with an arthritic pseudarthrosis of a sacralised transverse pro complains of low back pain This pain is localised to the site of the pseudarthr and is made worse by exertion and by certain movements

When root irritation is present the patient complains of pain of monoradic distribution felt in one leg

Clinical Signs

On examination of the low back the pain is referred fairly accurately to site of the pseudarthrosis Deep local tenderness is commonly present and th is pain in this area at the extremes of lateral flexion and rotation Some sp of the lumbar muscles is usual particularly on the affected side.

On examination of the legs there is pain referred accurately to the dermat of the affected root and the presence of root irritation is shown by limitatior straight leg raising. Sensory motor or reflex changes are not usually present.

Radiological Findings

Radiographs show an abnormal transverse process with an associa pseudarthrosis (Plate 11) and often there is narrowing of the joint between transitional vertebra and the solid sacrum Such narrowing does not necessa ndicate any disc abnormality since the joint may be partially rudimentary v a disc which is less thick than normal.

Differential Diagnosis

The sacralised transverse process with an arthritic pseudarthrosis is an common enough condition and even when it is present a particular anatom arrangement is necessary before it can be associated with root irritation It sho also be remembered that skeletal anomalies in the lumbar region are commo found in association with disc lesions

The presence of the sacralised transverse process and arthritic pseudarthr is shown by radiography The difficulty is to decide whether this condition or associated disc lesion is responsible for the patient's symptoms

The level of the root responsible for symptoms referred to the leg o provides a clue to the differential diagnosis. If the transverse process forming pseudarthrosis arises from the fifth lumbar vertebra the only root which can involved in arthritic changes is the fourth lumbar If a lumbarised first sa vertebra forms the false joint the fifth lumbar root is the only one which i be involved (Fig. 45) The first sacral root can never be in anatomical contact v such a pseudarthrosis. If the root symptoms do not correspond in level to arrangement the presence of an arthritic pseudarthrosis is a coincidental fin and is not responsible for the patient's symptoms.

Further the clinical findings in the low back in the presence of an arth pseudarthrosis are not those of a disc lesion Flattening of the normal lum lordosis is not present and lateral flexion and rotation are more limited and pai than flexion and extension Pain and deep tenderness are also more localised t is the case with a disc lesion.



PLATE 11

Sacralised transverse process with pseudarthrosis.

The transverse process of the fifth lumbar vertebra is in contact with the sacrum on one side. At the point of contact a pseudarthrosis has formed and is the site of arthritic changes.

A sacralised transverse process with a pseudarthrosis is an uncommon condition and even when present it is not usually associated with mono radicular sciatica Although it is possible that symptoms produced by such a condition may *from time* to time be wrongly ascribed to a disc lesion the reverse is in the author s opinion a much more common diagnostic error

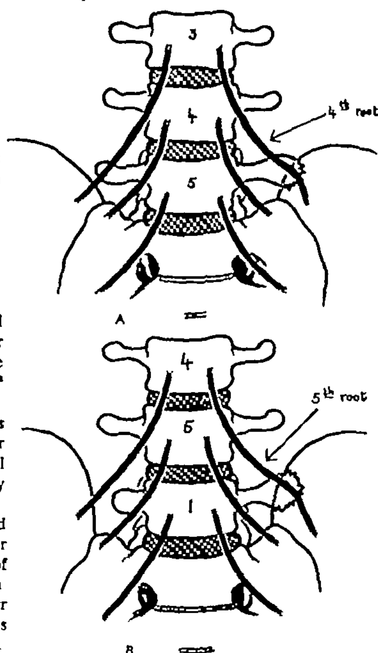


FIG. 45
Root relationship to pseudarthrosis formed by sacralised transverse process

If the abnormal transverse process is that of the fifth lumbar vertebra the root affected is the *fourth* lumbar (A) if the process is that of a lumbarised first sacral vertebra the root affected is the *fifth* lumbar (B) (*Note The first sacral root cannot be in relation to* such a pseudarthrosis.)

DEVELOPMENTAL NARROWING OF SPINAL CANAL

Local developmental narrowing of the lumbar canal may occur without any other associated abnormalities of the vertebral column (Sarpyener[3] Verbiest[4]).

Such localised strictures are sometimes responsible for symptoms and the clinical syndrome produced is fairly characteristic. Patients complain of lumbar backache and symptoms of polyradicular disturbances in the form of pain abnormalities of sensation and impairment of power in the legs. These symptoms occur when the patient is walking or standing and are relieved on lying down

Radiological examination of the lumbar spine usually shows no abnormality but myelography shows an obstruction in the lumbar canal On lumbar puncture the protein content of the cerebrospinal fluid may be raised

[3] Sarpyener Mumir Ahmed (1945) Congenital Stricture of the Spinal Canal. *J Bone Jt Surg.*, 27 70-79

[4] Verbiest, H (1954) A Radicular Syndrome from developmental narrowing of the Lumbar Vertebral Canal. *J Bone Jt Surg* 36B, 230-237

In the legs there may be evidence of unilateral or bilateral root irritation as shown by limitation of straight leg raising. Referred pain is rarely of a completely monoradicular distribution, however and is usually described as a general deep ache. Sensory motor or reflex changes are rarely associated with osteoarthritis. It should be noted particularly that, in the presence of five mobile vertebrae in the lumbar region and a normal plexus, the first sacral root cannot be involved directly in osteoarthritic changes since it leaves the spinal canal through the first sacral foramen.

The presence of signs of interference with the function of the first sacral root, that is, pain or anaesthesia in the first sacral dermatome, weakness of the muscles of the calf or loss of the ankle jerk can, in the presence of a normal lumbar spine, only be attributed to osteoarthritis by postulating a prefixed lumbar plexus.

Radiological Examination

The radiological evidence of osteoarthritis is definite in the later stages of the condition and some changes are almost always present by the time symptoms become severe. These changes are generalised throughout the lumbar spine and are not confined to one intervertebral joint as is the case with the degenerative changes which take place in the later stages of a disc lesion Gross narrowing of one intervertebral space is not a feature of uncomplicated osteoarthritis

When assessing the diagnostic value of radiological changes it should be remembered that the presence of osteoarthritis even in a marked degree by no means excludes the possibility of an associated disc lesion

Differential Diagnosis

Assessment of the patient s history the clinical signs and the X ray changes usually make it possible to differentiate confidently between a disc lesion and a spinal osteoarthritis. When the two conditions co-exist as is occasionally the case, it should be possible to diagnose the presence of a disc lesion in spite of the complicating factors produced by the presence of spinal arthritis.

SPONDYLITIS ANKYLOPOETICA

Early ankylosing spondylitis of the Spondylose Rhyzomelique of Strumpell Marie type may simulate a lesion of a lower lumbar intervertebral disc. Later in this disease the clinical picture and symptomatology become more characteristic but before this stage has been reached confusion may arise between the two conditions

Mechanism of Symptom Production

Symptoms in the lower back are produced by the chronic arthritic changes which take place both in the intervertebral and sacro-iliac joints.

Pain in the legs is usually attributed to involvement of the roots as they pass through the spinal foramina In this condition periarticular thickening fibrosis

finally calcification are the predominant features. These changes take place .d the posterior intervertebral articulations and might be expected partially clude the foramina Since the lumbar foramina decrease in size from above wards while the reverse is true of the lumbar roots, the lower roots might pected to be the first affected by foraminal occlusion The author considers ictual pressure on the roots as they leave the spinal canal is a rare phenomenon ms more likely that the roots become adherent to the walls of the foramina result of periarticular oedema and adhesion formation These adherent roots, ig lost their normal range of movement, are stretched and irritated by move s of the spine and legs

nt's History

In ankylosing spondylitis the first complaint is of lumbo-sacral backache which be felt only in this region or may extend into one or both buttocks The pain an intermittent character and is not markedly affected by exertion.

In many instances low back pain is followed by sciatica. This may be uni il, bilateral or alternating. It is not generally realised how often sciatic pain sociated with low back pain in the early stages of this condition Hart, inson Allchin and Maclagan,[1*] however report that 31 out of 43 patients tigated complained of sciatic pain at one time or another

Although backache and pain in the legs are usually the main complaints in early stages of spondylitis ankylopoetica, other symptoms are common. The nt may complain of stiffness or tightness in the chest, stiffness of the hips or scomfort and tenderness in the region of the ischial tuberosities.

ical Findings

In the early stages impaired movement of the lumbar spine is always present. movements are limited although flexion may be the most affected Spasm of lumbar muscles is present and may be severe Later there is increasing spinal iess, all regions being affected, and ultimately the whole vertebral column imes fixed

In the legs pain of monoradicular distribution is present and root irritation iown by limitation of and pain on straight leg raising. Sensory motor or reflex iges are unusual. Diminished thoracic expansion and limitation of hip move ts may be present.

iological Examination

A diagnosis of ankylosing spondylitis is usually ultimately confirmed by ographic changes in the spine and sacro-iliac joints. In the early stages, however only finding may be slight irregularity in the sacro-iliac region and it is only r that the more typical changes affecting the whole spine become evident (Plate A and B)

Hart, F D., Robinson, K. C., Allchin, F M., & Maclagan N F (1949) Ankylosing Spondylitis. *Quart J Med* 18, New Series, 217 234



PLATE 12A

Spondylitis ankylopoetica

The appearance of the lumbar spine is shown in a patient with spondylitis ankylopoetica of some ten years standing.

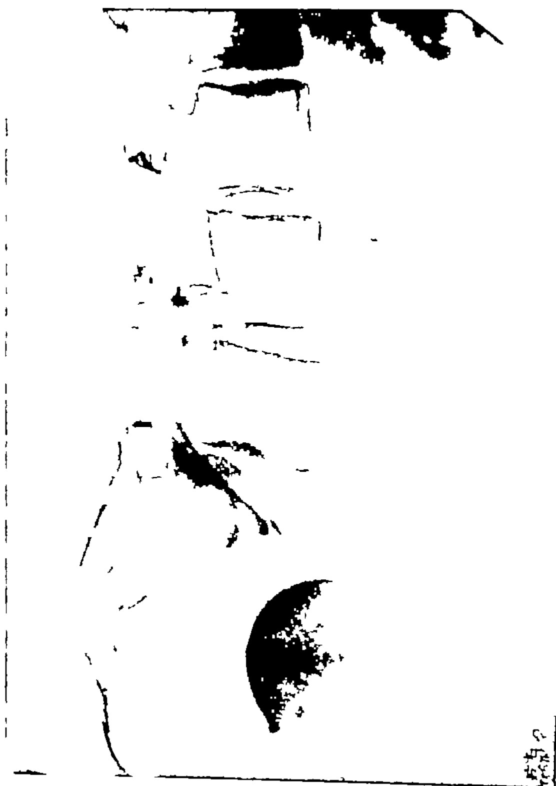


PLATE 12B
Same patient as Plate 12A. The hip joints were also affected. (Note the vitallium mould.)

Other Investigations

Even in the early stages the blood sedimentation rate is raised and this investigation should never be omitted if ankylosing spondylitis is suspected.

These patients usually exhibit a little irregular pyrexia

Differential Diagnosis:

In the later stages generalised stiffness of the spine, associated symptoms and the radiological changes make the diagnosis of ankylosing spondylitis clear

It is not always possible to differentiate with absolute confidence between a mild disc lesion of the degenerate type and *spondylitis ankylopoetica in the very* early stages. It is possible, however to say of such patients that the clinical picture is not typical of a disc lesion and that early ankylosing spondylitis may be present. If the patient is in fact suffering from ankylosing spondylitis this will become clear as a result of observation with serial X rays and repeated blood sedimentation rates over a period of a few months.

TUMOURS WITHIN THE SPINAL CANAL

Tumours within the lower part of the spinal canal, and in particular those affecting the cauda equina may in certain circumstances and at certain stages of *their growth, simulate closely or even exactly the symptoms of a lumbar disc lesion*

Indeed it is probable that most of the grave errors of diagnosis concerning patients complaining of symptoms in the low back and legs consist of failure to recognise a spinal tumour in its early stages. Since it is in the early stages that these growths are most amenable to surgical treatment, their prompt recognition is a *matter of great importance.*

It should be remembered that intraspinal tumours are responsible for the symptoms in about 5 per cent of all patients who require laminectomy for associated symptoms in the low back and in the leg. The differential diagnosis between a disc lesion and an intraspinal tumour is therefore a problem which frequently confronts all orthopaedic surgeons

BRIEF CLASSIFICATION OF INTRASPINAL TUMOURS

Since intraspinal tumours produce symptoms mainly by pressure it is not always possible to differentiate on clinical grounds alone between the various types. *Indeed the cellular pathology of these tumours,* particularly of those arising within the spinal cord and filum terminale, is so complex and the terminology of their nomenclature so varied that the orthopaedic surgeon may be excused if his diagnosis stops short at the comprehensive term intraspinal tumour

It is possible, however to produce a simple working classification of these growths, and the author has found the following of some assistance although it is not claimed that it is either complete or generally acceptable.

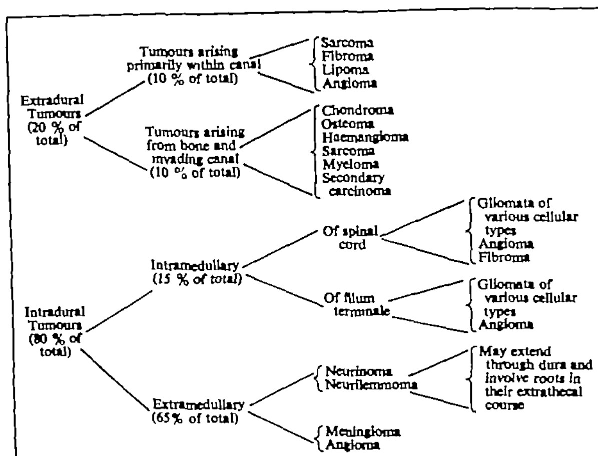
It will be seen that extradural tumours only account for one-fifth of all intra spinal neoplasms. Of these half arise within the spinal canal itself and may be

simple fibromata lipomata or vascular tumours, or rarely sarcomata The remainder invade the canal from adjacent vertebrae and may be simple chondromata, osteomata or vascular tumours, or sarcomata myelomata or secondary carcinoma. Extradural tumours particularly those arising from the vertebrae, occasionally occur in the lumbar or sacral regions and may mimic a disc lesion

Intradural tumours account for 80 per cent of all intraspinal tumours and may be divided into two groups

TABLE V

CLASSIFICATION OF INTRASPINAL TUMOURS



Intramedullary tumours that is, tumours of the spinal cord or filum terminale, are the least common of the intradural group accounting for only 15 per cent of all intraspinal growths. Tumours of the cord and filum terminale are of much the same type, gliomata of various cellular structures, angiomata and in the cord, occasional fibromata Of the cordal gliomata the following types have been reported —ependymoma, astrocytoma astroblastoma, polar spongioblastoma and ganglioneuroma. Ependymoma, astrocytoma, spongioblastoma multiforme and oligodendroglioma have been reported in the filum terminale. Of these, ependymomata are the most common. As far as the differential diagnosis of lumbar disc lesions is concerned tumours of the filum terminale often cause difficulty but only those

tumours arising in the extreme lower end of the cord or conus medullaris produce symptoms in both the low back and legs

Extramedullary intradural tumours comprise the largest group, 65 per cent. of all intraspinal growths Of those tumours arising from the nerve roots, the neurinomata or neurilemmomata are the commonest. Such tumours sometimes extend through the theca and involve the roots in their extrathecal course. Tumours arising from the meninges, the *meningiomata* are also relatively common and are of various types Intradural angiomata are also reported from time to time The extramedullary intradural group accounts for most of the spinal tumours which simulate lumbar disc lesions.

Mechanism of Symptom Production

Intraspinal tumours which produce symptoms in the low back and leg do so by pressure either on the lower spinal cord or on the roots of the cauda equina. The degree and extent of the symptoms depend on the site, consistency and size of the tumour and to a less extent on the size of the canal. In certain circumstances one root alone may be affected, particularly by a neurinoma but sooner or later other roots become involved. The rate of growth of the tumour has a profound effect on the development or march of symptoms.

In the lower part of the spinal canal the relationship between the level of the tumour and the symptoms it produces is complex. Because of their long intraspinal course the roots of the cauda equina are exposed to pressure from tumours occurring anywhere in the lumbar region. For example the function of the first sacral root may be affected by a tumour of the lower cord conus medullaris or filum terminale or by an extramedullary tumour either intra or extradural, situated anywhere between the twelfth dorsal and second sacral vertebrae When a spinal tumour completely occludes the canal so that the function of the cord or roots at and below its level is interrupted, the clinical picture becomes clear and the site of the growth may be determined on clinical grounds alone Complete occlusion with generalised pressure symptoms is an end stage however and surgical treatment is indicated long before it is reached In most slowly-growing tumours it is impossible to diagnose the site of the tumour accurately on clinical grounds alone and its position must be determined by myelography if widespread surgical exploration is to be avoided

Symptoms of Intraspinal Tumours:

The onset of the symptoms of an intraspinal tumour is insidious *Pain* felt in the low back is common, usually taking the form of a localised dull ache. Pain in the legs is also one of the commoner early symptoms. Characteristically the pain is felt in both legs and is not accurately localised Pain may be referred to the thighs, to the groins or to the distribution of the sciatic nerve. A clearly-defined pain of monoradicular distribution is uncommon although it does occur with some tumours.

A feeling of weakness and numbness in both legs is a common symptom and is not necessarily associated with pain Such patients complain that their legs feel heavy or that their legs feel as if they did not belong to them

Bladder or rectal symptoms are severe and appear early in association with tumours of the conus medullaris, but only occur in the later stages of tumours of *the filum terminale or cauda equina.*

Symptoms associated with intraspinal tumours are steadily progressive and are unaffected by rest or by any form of conservative treatment

Clinical Signs

On examination of the low back spasm of the lumbar muscles is commonly found In the case of tumours arising from the vertebral bodies, all spinal movements are limited and the affected vertebra is tender on heavy percussion Gross limitation of movement is not characteristically associated with other spinal tumours and postural deformities are uncommon

On examination of the legs, root irritability as shown by pain on stretching, is an early sign Sensory motor or reflex changes may be noted or may develop depending on the degree and extent of interference with root function

Examination of Cerebrospinal Fluid

The protein content of the cerebrospinal fluid is raised in the presence of a tumour obstructing the subdural space. In all doubtful cases the cerebrospinal fluid should be examined and a raised protein is very suggestive of the presence of a tumour It should be remembered, however that in the early stages the protein content may be normal.

Radiological Examination

Tumours arising from the vertebral bodies are visible on radiological examination of the lumbar spine.

Myelography

Myelography is probably the most important single step in the diagnosis of spinal tumours. Pantopaque appears to be the most reliable contrast medium. It is heavier than and does not mix with the cerebrospinal fluid and if left in the subarachnoid space it is said to be slowly absorbed It is less irritant than Lipiodol and produces a much better contrast than oxygen

In the presence of an intraspinal tumour of a size sufficient to cause symptoms, careful examination of the lumbar region from a wide variety of angles with the patient on a tilting table does, in the majority of patients, disclose a filling defect. This defect not only confirms the presence but indicates the position of the tumour

While myelography is indicated when the presence of a spinal tumour is suspected this examination is by no means without its dangers both immediate and late, and should never be undertaken lightly or without good reason

Differential Diagnosis:

In all patients with symptoms suggestive but not typical of a disc lesion, the possibility of an intraspinal tumour should always be borne in mind. The insidious onset of symptoms, their unremitting progress and the clinical evidence of increasing root involvement are suggestive of a neoplasm a raised protein content on examination of the cerebrospinal fluid reinforces the diagnosis and myelography should supply the final evidence.

A low intraspinal tumour is an obscure condition and patients may have to be kept under observation for some time before the diagnosis can be arrived at Routine myelography in such patients is, in the author's opinion both unreliable and unjustifiable but it should always be remembered that if a tumour is present the earlier the diagnosis is made the greater are the chances of achieving a complete cure by surgical removal of the neoplasm.

OSTEITIS DEFORMANS (PAGET'S DISEASE)

Osteitis deformans *may affect the spinal column, when it not uncommonly* occurs in the lumbar region. From time to time patients whose main complaints are of pain in the low back and legs are found to be suffering from this condition

Mechanism of Symptom Production:

Changes in the vertebral bodies are associated with a deep aching pain felt in the affected region of the spine.

The sub-periosteal deposition of bone which occurs in osteitis deformans may cause narrowing of the spinal foramina, particularly when the pedicles and articular processes are affected The nerve roots may then be involved as they pass through the narrowed foramina, with consequent symptoms of root irritation or even root compression.

When the lumbar region is affected in this way the symptoms produced may be somewhat similar to those associated with disc lesions.

Patient's History

Patients suffering from osteitis deformans affecting the lumbar spine complain of aching pain felt in the low back The pain is not related to activity or exertion and is not relieved by rest, nor is it episodic in character

When root irritation is present the patient complains of pain felt in the legs This pain may be unilateral or bilateral and monoradicular or multiradicular depending on the number of roots involved

Osteitis deformans rarely affects the spinal column only and changes usually occur in other parts of the skeleton. These are associated with the symptoms typical of the condition.

Clinical Signs

In the low back the usual findings are of slight muscle guarding, slight uniform limitation of movements and tenderness on heavy percussion

In the legs the signs are those of root irritation and less commonly compression Pain on stretching the affected roots is present and if the root function is disturbed sensory changes muscle weakness or reflex changes may be present. Occasionally one root only is involved by the foraminal changes and symptoms may then be monoradicular and unilateral More often when the roots are affected this occurs more or less uniformly throughout the diseased area of the spine although in the lumbar region the lowest roots, being the largest in relation to the size of the foramina through which they pass, tend to be the first affected by pressure.

It should be remembered when dealing with osteitis deformans of the lumbar spine that if the bones of the legs are also affected as is quite often the case these local changes produce the deep aching boring pain characteristic of the condition This pain is of course due only to the local changes and does not in these circumstances indicate root involvement.

Radiological Examination

Radiological examination of the lumbar spine reveals the changes typically associated with osteitis deformans and general examination of the skeleton usually shows similar changes elsewhere.

Differential Diagnosis

Although from time to time osteitis of the lumbar spine produces symptoms somewhat similar to those of disc lesions, the differential diagnosis between the two conditions is not a matter of great difficulty The presence of symptoms associated with bony changes elsewhere in the skeleton and the typical radiological appearance usually makes the diagnosis simple The author has never observed a disc lesion in association with osteitis deformans On one occasion he had to perform a foraminotomy to relieve intractable monoradicular sciatica associated with this condition The disc at the level of the obstructed foramen and the disc above were both inspected closely and appeared normal

OSTEOMYELITIS OF THE LUMBAR SPINE WITH ABSCESS FORMATION

Very occasionally osteomyelitis of the spine with a local abscess formation may simulate a disc lesion by producing symptoms in the back and legs

Mechanism of Symptom Production

An inflammatory lesion in one of the lumbar vertebrae produces severe pain in the lower back with associated limitation of movement and muscle spasm.

When local abscess formation takes place the abscess may point backwards into the spinal canal A large abscess may partially occlude the canal and cause pressure on the cauda equina, while a small abscess in the region of the intervertebral disc may involve the adjacent roots in their extrathecal course.

Patient's History

An osteomyelitis in the lumbar region produces severe pain in the low back. This pain is of fairly rapid onset and is unremitting in character Some slight relief may be produced by rest in the completely supine position

If an abscess involves the spinal canal the initial symptoms may be pain of monoradicular distribution This is followed by the symptoms of cauda equina pressure and usually by those of meningitis.

The patient also complains of the general symptoms of toxicity produced by an acute focus of infection somewhere in the body

Clinical Signs

On examination of the low back extreme spasm of the lower lumbar muscles with gross limitation of and pain on all movements is present The lumbar spine is usually held completely fixed by muscle spasm

In the legs the signs of root irritation, pain and limitation of straight leg raising may be present Later the signs of cauda equina pressure, sensory change, muscle weakness or reflex changes may be present.

Meningitis is almost always a rapidly-occurring complication of an abscess pointing into the spinal canal and the early signs of this complication are usually present in such patients.

Other Investigations

In the presence of a spinal osteomyelitis a raised temperature an increased white cell count and a raised sedimentation rate indicate the presence of an acute infection

Radiological Changes

Localised rarefaction and later bone destruction occur in the affected vertebra at the site of the infection Radiological changes do not appear in the earlier stages of the infection and may not become visible for between seven and fourteen days after the onset of symptoms

Differential Diagnosis:

Osteomyelitis of a lumbar vertebra is a very uncommon condition and does not really simulate a disc lesion very closely It is true that in the early stages the condition of the low back might suggest a sudden nuclear protrusion, but the signs of infection should indicate the presence of an inflammatory lesion In those very rare cases in which an abscess invades the spinal canal the signs of bone infection should be obvious by the time symptoms of root or cauda equina involvement appear Most of the diagnostic errors which occur in connection with lumbar osteomyelitis arise because it is such an uncommon condition that, in spite of ample clinical evidence, its presence is not suspected until it becomes obvious.

TUBERCULOSIS OF THE LUMBAR SPINE

Although the lower lumbar region is less often affected than other areas in the spine it may be the site of a tuberculous lesion Such an infection may produce symptoms referable both to the back and to the legs and when these symptoms occur in the earlier stages of the infection the clinical picture may be somewhat similar to that produced by a disc lesion

Mechanism of Symptom Production

Tuberculosis of a lumbar vertebra is invariably and from its earlier stages associated with some symptoms referred to the low back

Ordinarily the infection starts in a vertebral body and progressive destruction of bone finally causes collapse of the vertebral body with angulation and deformity of the spine. At this stage some degree of abscess formation is usual From time to time such abscesses extend backwards into the spinal canal and spread around the cauda equina in the extradural space. Pressure from the abscess and from granulomatous debris, possibly complicated in some instances by spinal angulation may affect the roots of the cauda equina and produce symptoms referred to the legs

This, the classical sequence of events leading to cord or cauda equina involvement in tuberculosis of the vertebral column is unlikely ever to be confused with a disc lesion Long before the stage of cord involvement has been reached abundant evidence of the true nature of the condition is obvious.

There is, however another and much less common type of spinal tuberculosis which mimics a disc lesion closely The primary focus appears to arise in the vertebral body close to the intervertebral disc. Contrary to the usual course of the disease, when the disc appears to resist infection longer and to be destroyed later than the adjacent bone the disc itself is involved in the infection quickly before there are any visible changes in or any collapse of the vertebral body Some local destruction of the disc takes place and an abscess forms This may point backwards into the vertebral canal and come into contact with the nerve ro s which cross he d sc in their extrathecal course An abscess pointing in this way produces symptoms of root irritation or compression in exactly the same way as a posterior retropulsion of the nucleus pulposus The root symptoms associated wi h a lesion of this type are therefore exactly similar to those of a disc lesion and the low back symptoms are sufficiently similar to cause some difficulty in differential diagnosis

Patient s History

The patient with tuberculosis of the lumbar spine complains of severe low back pain. The pain is of gradual onset but progresses steadily being made worse by movement, exertion and activity It is only partially relieved by rest and is not episodic in character

The symptoms in the legs associated with the ordinary type of extradural abscess are characteristically those of a spinal tumour and depend on the degree

Patient's History

An osteomyelitis in the lumbar region produces severe pain in the low back. This pain is of fairly rapid onset and is unremitting in character. Some slight relief may be produced by rest in the completely supine position.

If an abscess involves the spinal canal, the initial symptoms may be pain of monoradicular distribution. This is followed by the symptoms of cauda equina pressure and usually by those of meningitis.

The patient also complains of the general symptoms of toxicity produced by an acute focus of infection somewhere in the body.

Clinical Signs

On examination of the low back, extreme spasm of the lower lumbar muscles with gross limitation of and pain on all movements is present. The lumbar spine is usually held completely fixed by muscle spasm.

In the legs the signs of root irritation, pain and limitation of straight leg raising may be present. Later the signs of cauda equina pressure, sensory change, muscle weakness or reflex changes may be present.

Meningitis is almost always a rapidly-occurring complication of an abscess pointing into the spinal canal and the early signs of this complication are usually present in such patients.

Other Investigations:

In the presence of a spinal osteomyelitis a raised temperature, an increased white cell count and a raised sedimentation rate indicate the presence of an acute infection.

Radiological Changes:

Localised rarefaction and later bone destruction occur in the affected vertebra at the site of the infection. Radiological changes do not appear in the earlier stages of the infection and may not become visible for between seven and fourteen days after the onset of symptoms.

Differential Diagnosis

Osteomyelitis of a lumbar vertebra is a very uncommon condition and does not really simulate a disc lesion very closely. It is true that in the early stages the condition of the low back might suggest a sudden nuclear protrusion, but the signs of infection should indicate the presence of an inflammatory lesion. In those very rare cases in which an abscess invades the spinal canal the signs of bone infection should be obvious by the time symptoms of root or cauda equina involvement appear. Most of the diagnostic errors which occur in connection with lumbar osteomyelitis arise because it is such an uncommon condition that, in spite of ample clinical evidence, its presence is not suspected until it becomes obvious.

TUBERCULOSIS OF THE LUMBAR SPINE

Although the lower lumbar region is less often affected than other areas in the spine, it may be the site of a tuberculous lesion. Such an infection may produce symptoms referable both to the back and to the legs and when these symptoms occur in the earlier stages of the infection the clinical picture may be somewhat similar to that produced by a disc lesion.

Mechanism of Symptom Production

Tuberculosis of a lumbar vertebra is invariably and from its earlier stages associated with some symptoms referred to the low back.

Ordinarily the infection starts in a vertebral body and progressive destruction of bone finally causes collapse of the vertebral body with angulation and deformity of the spine. At this stage some degree of abscess formation is usual. From time to time such abscesses extend backwards into the spinal canal and spread around the cauda equina in the extradural space. Pressure from the abscess and from granulomatous debris, possibly complicated in some instances by spinal angulation, may affect the roots of the cauda equina and produce symptoms referred to the legs.

This, the classical sequence of events leading to cord or cauda equina involvement in tuberculosis of the vertebral column, is unlikely ever to be confused with a disc lesion. Long before the stage of cord involvement has been reached abundant evidence of the true nature of the condition is obvious.

There is, however, another and much less common type of spinal tuberculosis which mimics a disc lesion closely. The primary focus appears to arise in the vertebral body close to the intervertebral disc. Contrary to the usual course of the disease, when the disc appears to resist infection longer and to be destroyed later than the adjacent bone, the disc itself is involved in the infection quickly before there are any visible changes in or any collapse of the vertebral body. Some local destruction of the disc takes place and an abscess forms. This may point backwards into the vertebral canal and come into contact with the nerve roots which cross the disc in their extrathecal course. An abscess pointing in this way produces symptoms of root irritation or compression in exactly the same way as a posterior retropulsion of the nucleus pulposus. The root symptoms associated with a lesion of this type are therefore exactly similar to those of a disc lesion and the low back symptoms are sufficiently similar to cause some difficulty in differential diagnosis.

Patient's History:

The patient with tuberculosis of the lumbar spine complains of severe low back pain. The pain is of gradual onset but progresses steadily being made worse by movement, exertion and activity. It is only partially relieved by rest and is not episodic in character.

The symptoms in the legs associated with the ordinary type of extradural abscess are characteristically those of a spinal tumour and depend on the degree



PLATE 13

Tuberculosis of lumbar spine simulating a disc lesion

The patient complained of low back pain of two months duration and of some unilateral sciatic pain of fifth root distribution. The radiograph showed L.4 L.5 narrowing without any marked changes in the vertebral bodies and the condition could have been attributed to a disc lesion Because of the clinical findings and the nature of the narrowing, tuberculosis was suspected and the patient was immobilised in a plaster bed. Two months later bone destruction was obvious

and extent of root involvement. The small abscess localised to the region of the intervertebral disc produces monoradicular pain either unilateral or bilateral

Clinical Manifestations

On examination of the lumbar spine there are two findings characteristically associated with a tuberculous infection A generalised spasm of the lumbar muscles is present producing flattening and rigidity of the lumbar region All movements are uniformly and grossly limited and attempted movement is associated with severe pain

In the later stages collapse of the vertebral body may produce a kyphotic deformity of the spine.

In those infections associated with vertebral collapse and a large extradural abscess the symptoms in the legs depend on the degree and extent of root involvement. Referred pain sensory change, muscle weakness or reflex changes may be present.

The less usual type of small abscess localised to the region of the intervertebral disc produces symptoms of irritation or compression of a single root either unilateral or bilateral.

Radiological Examination

In the ordinary type of tuberculous infection changes in the vertebral bodies can almost always be detected without difficulty on radiological examination by the time symptoms become severe The more local type of infection is not so easily seen, however and abscess formation may occur in the region of the disc before the changes in the vertebra have become obvious (Plate 13)

Other Signs of Infection

Tuberculosis of the lumbar spine is associated with the usual general signs of a tuberculous infection somewhere in the body Some degree of evening pyrexia is almost always present and there may be general malaise and loss of weight, energy and appetite

A raised blood sedimentation rate often provides an early and valuable clue to the presence of an inflammatory lesion in the spine.

Differential Diagnosis:

The usual and more florid type of spinal tuberculosis should not be confused with a disc lesion Radiological evidence of bone destruction and the signs of an infective focus are fairly obvious and the clinical pictures are not very similar

The much rarer small abscess in the region of the disc however simulates a disc lesion very closely The type of sciatic pain produced by the two conditions may be identical and the signs in the low back are not very different The bony changes may not be visible unless really first class radiographs are available and the general signs of infection may be overlooked From time to time such abscesses are discovered on laminectomy for a suspected disc lesion

CHAPTER XI

THE DIFFERENTIAL DIAGNOSIS OF LUMBAR DISC LESIONS

(Continued)

LESIONS ASSOCIATED WITH LOW BACK PAIN

THERE are very few individuals who are fortunate enough to go through life without having some pain in the low back at one time or another This is not surprising since, from the mechanical point of view the lumbo-sacral spine is one of the regions which have suffered most from the adoption of the upright position. The mechanical stresses to which the tissues are subjected are greater here than anywhere else in the body and there is also an abrupt change in the direction of forces transmitted along the spinal column. It is therefore to be expected that the low back should be the site of various disorders and of pathological changes produced either by injury or by wear and tear

The more common causes of low back pain have been classified in Table VI Some of these also produce symptoms referred to the legs and have been dealt with in a previous chapter

1 DEVELOPMENTAL DEFECTS

The first group are the more usual developmental abnormalities found in the lumbar and lumbo-sacral regions. These anomalies or variations from the accepted normal are extremely common and are not always associated with symptoms. Indeed, their significance is a matter of considerable controversy and there is no doubt that in the past too much importance was attributed at least to some of these conditions

The more common developmental anomalies can be classified into seven groups. There are of course, many other rare abnormalities which are encountered from time to time and which produce symptoms. These are so seldom seen, however that they need not be considered here

(a) Spondylolisthesis:

This condition in which a defect passing between the upper and lower articular facets separates the posterior part of the neural arch from the anterior part of the vertebral body and allows anterior displacement of the latter is comparatively common The fifth lumbar vertebra is most often affected and the degree of anterior displacement of the vertebral body which carries with it the spine above varies a great deal.

This condition is nearly always associated with low back pain although this pain may not develop until middle life Since spondylolisthesis is very often

associated with root irritation and symptoms referred to the legs it has been discussed already

As far as the low back is concerned the increased lumbar lordosis the typical dimple and the unmistakable radiological appearances (Plates 10A and 10B) make the diagnosis simple in most cases.

TABLE VI

CONDITIONS CAUSING LOW BACK PAIN

	Condition	Types
I	Lumbar Disc Lesions	
II	Developmental Defects	(a) Spondylolisthesis. (b) Spondylolysis. (c) Abnormalities in the number of mobile vertebrae in the lumbar region. (d) The transitional vertebra (e) Abnormalities of the posterior articular facets. (f) Spinous process impingement. (g) Spina Bifida. (h) Developmental narrowing of spinal canal (i) Malformation of spinal roots and sheaths.
III.	Traumatic Lesions	(a) Myofascial strains. (b) Ligamentous strains and tears. (c) Sacro-iliac strain (d) Lumbo-sacral strain (e) Fracture of vertebral body (f) Fracture of transverse processes.
IV	Postural strains.	
V	Degenerative Arthritis (Osteoarthritis).	
VI.	*Intraspinal Neoplasms.*	
VII.	Conditions associated with Pregnancy	
VIII.	Inflammatory Lesions of Lumbar Spine	Osteomyelitis. Tuberculosis.
IX.	Infections of Sacro-iliac Joints	Non-tuberculous. Tuberculous.
X.	Spondylitis Ankylopoetica (Spondylose Rhyzomelique of Strumpell Marie).	
XI.	Spondylitis	Infective Non infective (Rheumatic).
XII	Paget s Disease	
XIII.	Senile Osteoporosis.	
XIV	Acute Myositis (Fibrositis) (Fibromyositis) (' Lumbago ').	
XV	Vertebral Osteoarthropathy (Charcot s Disease of the Spine).	
XVI.	Pain referred from Pelvic Viscera	

(b) Spondylolysis :

Spondylolysis may be regarded as spondylolisthesis in the early or pre displacement stage. In this condition a defect either unilateral or bilateral passing

between the upper and lower articular processes in the neural arch of one vertebra This defect was formerly thought to be due to an abnormality in the mode of ossification of the arch which was said to develop from two centres on each side instead of from the normal one, with a failure of fusion between the anterior and posterior parts. More recently it has been suggested that the defect is either an ordinary fracture or a fatigue fracture which occurs in association with an abnormal thinness of the arch in this area. In spondylolysis as opposed to spondylolisthesis no separation takes place at the site of the defect.

The characteristic symptom of spondylolysis is an aching pain in the low back This pain is not episodic in character and is neither severe nor incapacitating. It is aggravated by exertion or by long periods of standing or walking and is markedly relieved by rest.

On examination of the low back there are no very definite clinical findings. A little spasm of the lumbar muscles is usually associated with slight discomfort at the extremes of all movements of the lumbar spine There is, however no postural deformity no great limitation of any movement and no evidence of root involvement.

The diagnosis is confirmed by radiological examination Good oblique views of the lumbar spine show a linear defect with some surrounding sclerosis, the defect passing between the upper and lower articular processes (Plate 14) It must be emphasised that these defects are only visible in oblique views of good quality and radiological examination in which antero-posterior and lateral views only are taken or in which the bone texture is not clearly defined fails to reveal the presence of a spondylolysis.

(c) Abnormalities in the Number of Mobile Lumbar Vertebrae:

Normally there are five mobile vertebrae in the lumbar region but variations in this number are comparatively common Apparent variations are produced by abnormalities in the lower dorsal region thirteen or eleven pairs of ribs instead of the normal twelve producing an apparent decrease or increase in the number of lumbar vertebrae. True variations are produced by sacralisation of the lowest lumbar vertebra or lumbarisation of the first sacral vertebra. The latter is the more common abnormality six mobile vertebrae in the lumbar region being more often encountered than four (Plates 15 and 16)

It is doubtful if these variations are of themselves significant It has been suggested that the increased mobility associated with six lumbar vertebrae renders the patient more liable to postural strains and the same suggestion has been made about the decreased mobility associated with four lumbar vertebrae In the author's view such suggestions are not very convincing

It is certain however that variations in the number of mobile lumbar vertebrae are often found in association with lesions of the lower lumbar intervertebral discs and the possibilities of the significance of these anomalies in the aetiology of disc lesions has been discussed already



PLATE 14
Spondylolysis
The linear defect with surrounding sclerosis passing between the upper and lower articular processes in one neural arch is clearly shown (Most people will be familiar with the series of Scottish Terriers shown in oblique views of the lumbar spine. If a spondylolysis is present the lower terrier is wearing a collar)

Not uncommonly a patient complaining of low back pain is found on radiological examination to have either six or four mobile vertebrae in the lumbar region It is only with the greatest reluctance, however and after careful consideration of the possibility of the presence of a disc lesion, that the patient's symptoms should be attributed to the vertebral abnormalities

(d) The 'Transitional Vertebra'

The process of sacralisation of the lowest lumbar vertebra or lumbarisation of the upper sacral vertebra is quite often incomplete and when this happens the affected vertebra is only partially free The joint between its body and the solid sacrum is narrower than normal and the disc occupying this space is rudimentary One or both transverse processes may be either in contact with or completely fused to the sacrum or ilium or in some instances, these processes may only be much closer to the bony pelvis than normal. This type of partially free vertebrae *is conveniently termed a transitional vertebra (Plates 16 and 17)*

The transitional vertebra may produce low back symptoms in three ways. (*i*) Degenerative arthritis of the rudimentary joint between the vertebral body and the solid sacrum is relatively common.

Such arthritis is associated with low back pain developing in middle life. This pain is not severe or incapacitating, is made worse by violent exertion and is partially relieved by rest.

On examination of the low back some muscle spasm and discomfort at the extremes of movement are usual but there is no postural deformity no gross limitation of movement and no symptoms of root involvement

Radiological examination shows some bone sclerosis and osteoarthritic lipping of the vertebral bodies and the diminished interspace.

It is important that this condition should be distinguished from a disc lesion in the later or degenerative stages. The arthritis is due to degenerative changes in a rudimentary and abnormal joint rather than to the changes which occur in a normal joint disorganised by disruption of a previously normal intervertebral disc.
(*ii*) Arthritis of a false joint between one or both transverse processes of a transitional vertebra has been discussed in a previous section. This condition produces *low back pain and may in certain circumstances, also produce root irritation*
(*iii*) Crowding of the transverse processes of a transitional vertebra, that is a decrease in the distance between these processes and the pelvis, may produce symptoms. If the processes actually come into contact with the pelvis on movement of the spine this impingement may be associated with pain or discomfort In the author's view this is a very uncommon cause of low back pain

(e) Abnormalities in the Plane of the Posterior Articular Facets:

Normally the articular facets in the posterior intervertebral joints of the lumbar spine lie approximately in the antero-posterior plane The only exceptions to this are the lumbo-sacral facets which lie in the coronal plane While this is the normal arrangement variations *in these planes, either unilateral or bilateral* are

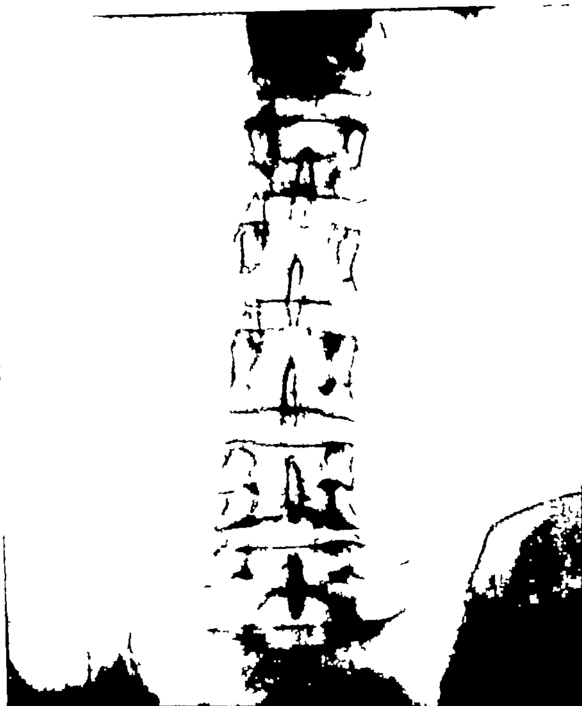


PLATE 15
Six mobile vertebrae in the lumbar region

common, particularly in the lower lumbar or lumbo sacral joints Formerly much significance was attached to such variations which were said to be important predisposing factors in the production of arthritic changes in the posterior joints. These changes were said to be associated not only with low back pain but also with involvement of the roots as they pass through the foramina

In the author's view isolated arthritis of a posterior intervertebral joint is not produced by abnormalities in the plane of the articular facets. These abnormalities are very commonly seen in association with disc lesions and the arthritic changes, when they occur are the sequel of a disc lesion being due to the secondary disorganisation of the posterior joints produced by such a lesion.

(f) Spinous Process Impingement:

If the spinous processes of the lower lumbar or first sacral vertebrae are larger than normal actual contact between these processes may occur on extension of the spine False joints may develop between the processes the bone at the point of contact being flattened covered with smooth fibrous tissue and surrounded by an adventitious bursa These joints may be the site of inflammatory changes and a source of pain.

The symptom of this condition is local pain which is aggravated by movement and particularly by extension of the spine On examination there is local tenderness and lateral radiographs show contact between the affected processes

In the author's opinion these kissing processes are comparatively common but rarely cause symptoms

(g) Spina Bifida:

Spina bifida or failure of posterior fusion of the neural arch of one of the lower lumbar or upper sacral vertebrae is very common

It has been suggested that a spina bifida is associated with a defect in the interspinous and supraspinous ligaments and that this defect produces the symptoms of low back strain In the author's view there is no very gross ligamentous defect associated with a simple spina bifida This condition is commonly found in association with lumbar disc lesions and on operating on these patients a powerful ligament is always found crossing the defect. It seems unlikely that a spina bifida alone is a cause of low back pain and symptoms probably only occur if the bony defect is associated with abnormalities of the meninges, spinal cord or cauda equina

(h) Developmental Narrowing of Spinal Canal:

Local strictures of the lumbar canal may be associated with low back pain and polyradicular symptoms in the legs. Characteristically these symptoms occur in the erect position and are relieved by lying down

Developmental narrowing of the lumbar canal is a rare condition and the final diagnosis can only be made by myelography The symptoms produced and the clinical findings do not simulate disc lesions very closely being much more suggestive of those produced by an intraspinal neoplasm.

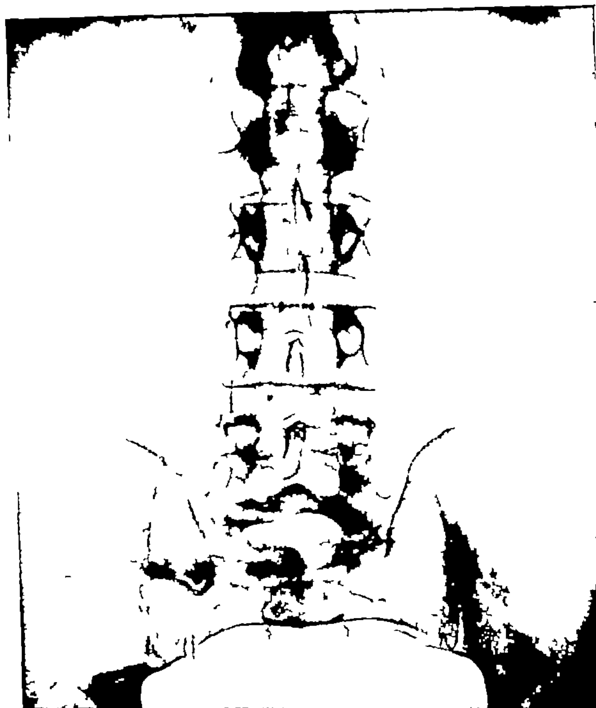


PLATE 16

Four mobile vertebrae in the lumbar region

The lowest lumbar vertebra is sacralised. (Note the pseudarthrosis on one side This vertebra is of the 'transitional' type)

(l) Malformation of Spinal Roots and Sheaths:

Developmental abnormalities of the lower lumbar roots or their sheaths may be associated with intermittent attacks of low back pain and monoradicular sciatica.

Both the clinical findings and the symptoms of these anomalies may mimic those produced by lumbar disc lesions exactly Radiographs of the lumbar spine are normal and the presence of these root abnormalities is only revealed by surgical exploration of the lumbar spine.

2. LOW BACK LESIONS CAUSED BY TRAUMA

The second group consists of those conditions due to trauma either in the form of a single injury or of minor strains repeated beyond the limits of tolerance of muscles, ligaments or joints

Before discussing these lesions in detail several of their general characteristics must be considered.

Of these the relationship between this type of low back disorder and sciatic pain is the most important. The lumbar muscles and fasciae, the intervertebral joints, the sacro-iliac joints and the lumbo-sacral joint derive a nerve supply from the posterior primary divisions of the lower lumbar and upper sacral roots. It has been stated that a lesion of these structures may produce referred sciatic pain and this has even been described as a reflex pain The phenomenon of referred pain has never been conclusively explained but it has been suggested that abnormal impulses of visceral origin are, in certain circumstances, interpreted as arising from that part of the body wall with a sensory nerve supply of the same root level as the affected organ While this seems to apply to pain associated with diseases of viscera having a purely autonomic nerve supply it is doubtful if a similar phenomenon occurs in diseases of muscles, ligaments or joints. These structures have a sensory nerve supply which, while it is not of the same nature is at least as adequate and as highly developed as the sensory nerve supply of the body wall. More, while the sensory mechanism of these structures is mainly concerned with kinaesthetic sensation there is no doubt that it can record painful stimuli very adequately and that pain so produced is localised to the region of the abnormal structure and not to a cutaneous area on the body wall.

It should also be pointed out that the posterior primary divisions which supply these structures have themselves a cutaneous distribution and that if disorders of the deep structures supplied by these nerves did produce referred pain this might be expected to be felt in the cutaneous distribution of the posterior divisions themselves rather than in the cutaneous distribution of the functionally and morphologically different anterior primary divisions of the same roots

In this connection reference must be made to the work of Kellgren.[1] He claimed that not only were disorders of structures supplied by the posterior primary divisions associated with referred sciatic pain but that, by injecting the site of the primary lesion with local anaesthetic, it was possible to prove conclusively that

[1] Kellgren, J H (1941) Sciatica. *Lancet* 240, 561

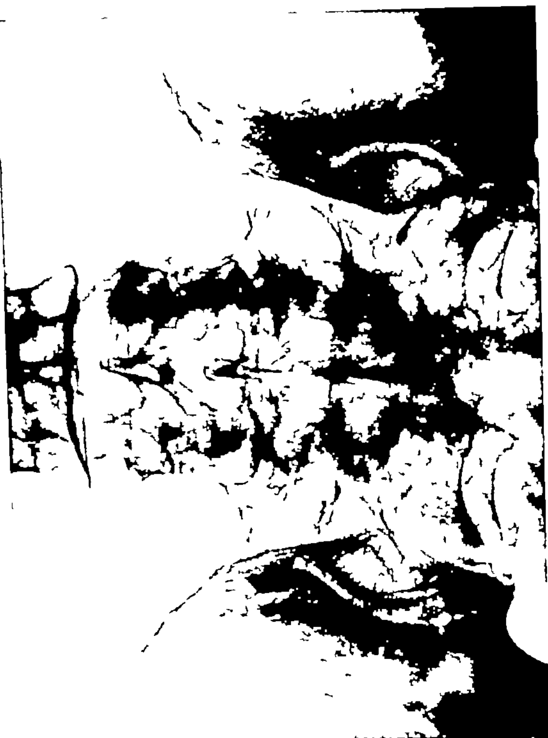


PLATE 17

Transitional vertebrae

The lowest lumbar vertebra is almost completely fused to the sacrum

(I) Malformation of Spinal Roots and Sheaths:

Developmental abnormalities of the lower lumbar roots or their sheaths may be associated with intermittent attacks of low back pain and monoradicular sciatica.

Both the clinical findings and the symptoms of these anomalies may mimic those produced by lumbar disc lesions exactly. Radiographs of the lumbar spine are normal and the presence of these root abnormalities is only revealed by surgical exploration of the lumbar spine.

2. LOW BACK LESIONS CAUSED BY TRAUMA

The second group consists of those conditions due to trauma either in the form of a single injury or of minor strains repeated beyond the limits of tolerance of muscles, ligaments or joints.

Before discussing these lesions in detail several of their general characteristics must be considered.

Of these the relationship between this type of low back disorder and sciatic pain is the most important. The lumbar muscles and fasciae, the intervertebral joints, the sacro-iliac joints and the lumbo-sacral joint derive a nerve supply from the posterior primary divisions of the lower lumbar and upper sacral roots. It has been stated that a lesion of these structures may produce referred sciatic pain and this has even been described as a "reflex" pain. The phenomenon of referred pain has never been conclusively explained but it has been suggested that abnormal impulses of visceral origin are, in certain circumstances, interpreted as arising from that part of the body wall with a sensory nerve supply of the same root level as the affected organ. While this seems to apply to pain associated with diseases of viscera having a purely autonomic nerve supply it is doubtful if a similar phenomenon occurs in diseases of muscles, ligaments or joints. These structures have a sensory nerve supply which, while it is not of the same nature, is at least as adequate and as highly developed as the sensory nerve supply of the body wall. More, while the sensory mechanism of these structures is mainly concerned with kinaesthetic sensation, there is no doubt that it can record painful stimuli very adequately and that pain so produced is localised to the region of the abnormal structure and not to a cutaneous area on the body wall.

It should also be pointed out that the posterior primary divisions which supply these structures have themselves a cutaneous distribution and that if disorders of the deep structures supplied by these nerves did produce referred pain this might be expected to be felt in the cutaneous distribution of the posterior divisions themselves rather than in the cutaneous distribution of the functionally and morphologically different anterior primary divisions of the same roots.

In this connection reference must be made to the work of Kellgren.[1] He claimed that not only were disorders of structures supplied by the posterior primary divisions associated with referred sciatic pain but that, by injecting the site of the primary lesion with local anaesthetic, it was possible to prove conclusively that

[1] Kellgren, J. H. (1941) Sciatica. *Lancet* 240, 561



PLATE 17

Transitional vertebrae

The lowest lumbar vertebra is almost completely fused to the sacrum.

this type of sciatica was in fact a referred phenomenon It was stated that such an *injection temporarily abolished* not only the local symptoms but the associated sciatica It must be pointed out that this work is not generally accepted and many observers do not believe that true sciatic pain occurs as referred pain in association with a local lesion in the low back if this lesion does not itself produce root irritation, a view which is shared by the author It is quite true that sciatic pain and pain referred to the low back *very commonly go hand in hand but in these* circumstances some irritant lesion is present somewhere in the course of a nerve root before it divides into its anterior and posterior primary divisions

The second point to be considered is the relationship between this group of disorders and the straight leg raising test. It has been suggested that pain on and limitation of straight leg raising is not necessarily associated with stretching of an irritable sciatic nerve but may be due to a local lesion in the low back Because raising of the straight leg produces some pelvic tilting this movement might be expected to cause pain and to be limited by muscle spasm if some muscle, ligamentous or joint injury was present in the lumbar region. Pelvic tilting only takes place in the last 30 degrees of straight leg raising, however and pain localised to the low back and felt before this arc is reached cannot be attributed to anything other than the stretching of an irritable, adherent or compressed nerve. Moreover two simple modifications of the test have already been described which exclude the possibility of a positive finding being associated with anything other than a nerve lesion. The extended leg is raised to a point just within the patient s tolerance, *the ankle being in full plantar flexion. When this point is reached* either full dorsiflexion of the ankle or full flexion of the cervical spine increases the tension in the nerve without either stretching the hamstrings or tilting the pelvis. Pain occurring on these movements is a positive indication of the presence of some condition which involves the sciatic nerve or its roots.

These two foregoing points have been very fully discussed at this juncture for two reasons. In the first place the author feels that in the past the various types of low back strain were far too commonly diagnosed and that these are rather unusual causes of severe and persistent symptoms. Secondly it is not now generally accepted that such lesions are associated with referred sciatica This being so the presence of sciatic pain in association with low back symptoms makes the diagnosis of one of this group of conditions untenable

The low back lesions produced by injury may now be considered individually and in detail

(a) Myofascial Strains

A single severe injury may cause local rupture of some fibres of the lumbar or gluteal muscles or fascia. This tearing may occur anywhere in these structures but is said to be commonest close to their insertion to bone

The symptoms associated with such strains are a sudden local pain at the moment of injury followed by persistent local discomfort which is sharply aggravated

by any movement or muscle contraction which stretches the damaged st As is usual with such injuries elsewhere symptoms tend to be very persistent

On examination the patient is able to localise the pain accurately and ten in this area is always present Movements which stretch the damaged s cause pain and the patient may assume a posture which relaxes or prevents in the damaged part.

In the early stages a haematoma or local bruising may provide a clue diagnosis but although some local bleeding is usual it may be too deeply to be visible or may spread along a fascial plane and only appear on the some distance from the site of its origin

One further test may be of help in the diagnosis of these strains Infi of the tender area with local anaesthetic temporarily abolishes all sy arising from such an injury

There can be no doubt that local tearing of muscle or fascial fibres do from time to time and that these injuries may cause pain and discom considerable periods They do not, however constitute one of the commone of low back pain and such a diagnosis should only be made after all more possibilities have been carefully excluded

(b) Ligamentous Strains or Tears

Injuries of the ligaments associated with the lumbo-sacral, sacro-il intervertebral joints are considered in connection with sprains of these join only other ligamentous structures in the lumbar region which might be tor partially or completely are the interspinous and supraspinous ligaments

Partial or complete rupture of both these ligaments occurs in associat fracture-dislocations of the lower lumbar spine. Occasionally partial rupt be produced by sudden flexion injuries without associated fractures or interv disc injuries. The symptoms of damage to the interspinous or supraspinous li are sharp local pain at the time of injury followed by local pain on fle the spine

On examination the patient refers symptoms accurately to the site o and localised tenderness with pain on and limitation of flexion are present.

Symptoms are completely abolished by infiltration of the painful ar local anaesthetic

Radiographic examination shows no abnormality Even after infiltrat local anaesthetic radiographs taken in full flexion show no apparent ab separation of the spinous processes

Like myofascial strains partial rupture of the inter and supraspinous li is an uncommon injury and such a diagnosis should only be made reluctantl

(c) Sacro-iliac Strain

Sacro-iliac strain probably shares with the kindred condition of lumb strain the doubtful distinction of being the most abused diagnosis co applied to low back disorders These two conditions form a sort of diagnost heap to which are consigned all patients with low back pain of obscure orig

Although the sacro-iliac is a synovial joint its main function is the transmission of weight, and architecturally its design is calculated to provide the maximum amount of stability The articular surfaces are irregular rather than flat and the irregularities on the sacral and iliac articular facets interlock and restrict joint movement. This locking device permits the transmission of weight without the production of ligamentous tension The sacro-iliac ligaments, in particular the interosseous sacro-iliac ligament, are themselves very strong and only permit a very limited range of joint movement. Normally slight antero-posterior rotation appreciably greater in the female than in the male, is the only movement which takes place at this joint.

Anatomically therefore the picture is of a powerfully protected and stable joint at which only a very limited range of movement is normally possible, a joint which habitually is subjected to powerful stresses and which would not appear likely to be affected by anything short of a very violent injury

The patient suffering from a sacro-iliac strain gives a history of injury immediately followed by pain localised to the sacro-iliac joint. This pain persists in the form of a dull and localised ache made worse by exertion and sharply exacerbated by rotatory movements of the pelvis

On examination the patient s pain is felt in the affected joint and deep tenderness is present in this area. Some local discomfort usually occurs at the extremes of all movements of the lumbar spine, this being most marked on rotation or lateral flexion away from the site of injury Sharp local pain may be produced on straining the affected joint by rotating the pelvis with the patient supine.

Radiological examination shows no abnormality Subluxations of the joint of a degree sufficient to be visible only occur in the puerperium in some paraplegic conditions and in association with fractures of the pelvic ring

It should be remembered that root irritation occurring in association with a disc lesion may produce pain and local tenderness referred very accurately to the region of the sacro-iliac joint. This occurs when the nerve fibres ultimately forming the posterior primary divisions bear the brunt of the intraspinal root involvement and is not necessarily associated with sciatic pain Such patients are often wrongly considered to be suffering from a sacro-iliac strain

(d) Lumbo-sacral Strain

The joint between the fifth lumbar vertebra and the sacrum differs from the lumbar intervertebral joints in several important respects. It is, with the exception of the sacro-coccygeal joint, the lowest joint in the vertebral column For this reason forces transmitted to the spine from the pelvis or the sacrum fall directly on the lumbo-sacral joint without being buffered in any way by being transmitted through a lower articulation The lumbo-sacral joint is situated at the only acute angle in the vertebral column this angulation being produced in part by the shape of the L.5 S 1 disc, and the transmission of force across an acute angle always presents mechanical difficulties Finally the plane of the posterior lumbo-sacral articular facets does not coincide with the plane of the other posterior lumbar

articulations. These features might be expected to make the lumbo-sacral joint more susceptible to injury than the other lumbar intervertebral articulations.

The patient suffering from a lumbo sacral strain gives a history of injury followed by pain felt in the lumbo-sacral region The initial more severe pain is subsequently replaced by dull aching with more acute pain on any sudden or extreme movement of the joint These symptoms are persistent moderately severe and aggravated by exertion.

On examination the symptoms are referred accurately to the joint and deep tenderness may be present in this region There is a little spasm of the lower lumbar muscles and slight limitation of all movements of the lumbar spine with pain or discomfort at the extremes of these movements Quite sharp local pain is often produced by extending the spine from a fully flexed position

Radiological examination of the lumbar spine shows no abnormality

It should be remembered that a lesion of the L.5 S 1 disc itself produces a disorganisation of the lumbo-sacral joint. The diagnosis of lumbo-sacral strain implies an injury to the joint in the form of a stretching or tearing of its supporting ligaments but without associated damage to the intervertebral disc Such an injury is probably quite uncommon and is certainly a much less common cause of chronic low back pain than a lesion of the L.5 S 1 disc. The diagnosis of lumbo-sacral strain should therefore only be made when it seems reasonably certain that no disc lesion is present.

(e) Crush Fracture of the Lumbar Vertebral Bodies

While crush fractures of the vertebral bodies occur most commonly in the lower dorsal region, the lumbar vertebrae, and particularly the upper lumbar vertebrae, are by no means immune to this injury Such fractures are usually of the flexion type with wedging of the injured body although from time to time crush fractures from an extension injury do occur

In the acute stages the patient gives a history of injury followed by local pain in the back Although this pain is immediate and severe in most instances, symptoms may be delayed for days or even weeks. Patients with old crush fractures complain of localised aching in the low back made worse by exertion.

In the acute stages symptoms arise from the fractured body itself In old fractures symptoms probably arise from the intervertebral joints above and below the fractured body These symptoms arise partly as a result of joint injury occurring at the time of the fracture and partly as a result of subsequent joint disorganisation produced by deformity of the vertebral body itself

On examination after a recent fracture there is spasm of the lower lumbar muscles, limitation of all movements of the lumbar spine with pain on forcing these movements and localised tenderness either to palpation or heavy percussion in the region of the fractured vertebral body With old injuries the findings are similar but less marked If the bony damage has resulted in a lateral as well as an antero-posterior wedging of the body a scoliosis is present.

The diagnosis of recent or old fractures is confirmed by X ray examination of the lumbar spine when either the fracture or deformity of the vertebral body is apparent.

Crush fractures of the lumbar vertebral bodies do not commonly simulate a disc lesion. From time to time, however particularly in those fractures in which there is some delay between the injury and the onset of symptoms, the presence of a fracture may not be suspected until it is revealed by radiological examination.

(f) Fractures of the Lumbar Transverse Processes

Quite commonly as a result of a severe injury the transverse processes of the lumbar vertebrae are fractured. These fractures are produced by an avulsion of the transverse processes associated with widespread tearing of the psoas muscle and are not the result of direct injury Because of the associated muscle damage symptoms tend to be very persistent.

Patients with such fractures give a history of injury followed by pain felt in one or other side of the lumbar region This pain is aggravated by any movement which stretches the affected muscle and by exertion.

On examination there is unilateral muscle spasm limitation of and pain on all movements which stretch the lumbar muscles on the affected side and there may be some deep tenderness at the site of the injury

Radiological examination reveals the bony damage to the transverse processes and establishes the diagnosis.

Fractures of the transverse processes of the lumbar vertebrae are important mainly because of the associated muscle damage. While such injuries may well be the cause of persistent pain this is usually described as being in the flank rather than in the low back. The injuries do not often mimic the symptoms associated with a lumbar disc lesion.

3 POSTURAL STRAINS OF THE LOW BACK

Normally the relationship maintained between the individual lumbar vertebrae and between the fifth lumbar vertebra and the sacrum is such that major mechanical stresses are transmitted through bone and through the intervertebral discs and do not fall directly on the intervertebral ligaments or on the spinal muscles If some abnormality of posture exists however these forces may no longer be transmitted in the normal way and may fall in part or in whole and either directly or indirectly on the various ligaments and even on the spinal muscles

Alterations in the normal lumbar posture may take the form of a lateral curvature, an exaggeration or diminution of the normal antero-posterior curvature, a rotatory deformity or commonly a combination of two or more of these deformities Paralysis, weakness under-development or imbalance of the spinal muscles, abnormalities of the bony vertebrae themselves or inequality in the length of the legs are some of the more usual causes of the postural abnormalities When such an abnormality causes a constant tension on or stretching of any ligament or group of ligaments symptoms, arising from the ligaments themselves, are produced

Ultimately if the abnormal relationship between the vertebrae is maintained for many years degenerative changes take place in the intervertebral joints and a chronic arthritis develops Once this is established the symptoms arising from the arthritic joints overshadow the ligamentous symptoms At this stage, however the condition can no longer be designated a postural strain

The patient with a postural strain of the low back complains of a constant dull aching in the lumbo-sacral region being made worse by exertion and partially relieved by rest

On examination it is usually possible to detect the postural abnormality without much difficulty Scoliosis is quite obvious, rotatory deformity or an increase in the normal lordosis are less easily seen The deformity is not, of course confined to the lumbar region compensatory deformities are present in the dorsal and cervical spines. Movements of the lumbar region are comparatively full and pain free. Muscle spasm is absent or slight and there is no local tenderness It is usually possible to determine the primary cause of the postural deformity

Radiographs confirm the presence of the deformity but show no evidence of any other lesion.

The term a postural strain of the low back implies symptoms of a comparatively mild nature arising from stretched ligaments or muscles in the lumbo-sacral region. This stretching is produced by some alteration in the position relative to each other in which the lumbar vertebrae are normally held by muscle tone. The alteration in relationship may be very slight and is not associated with arthritic changes in the intervertebral joints The symptoms arising from this condition might perhaps be mistaken for the symptoms associated with a lumbar disc lesion in the early or degenerative stage The clinical findings associated with a postural strain, however are not those associated with a disc lesion

4 DEGENERATIVE ARTHRITIS (OSTEOARTHRITIS) OF THE LUMBAR SPINE

Spinal osteoarthritis is one of the more common causes of pain in the low back particularly in patients who have passed middle age This condition may be associated with root involvement and symptoms referred to the legs and has therefore been discussed in a previous section.

As far as the low back is concerned symptoms are due to arthritic changes which take place in the intervertebral joints, both the joint between the vertebral bodies and the posterior articulations being affected The changes in and around these joints are of the usual degenerative arthritic type and they occur earlier and are more marked in patients with some associated condition such as a fixed hip or an uncorrected short leg which throws an increased mechanical strain on the lumbar spine

Patients suffering from osteoarthritis of the lumbar spine complain of a constant dull ache in the low back Although this may be made worse by severe exertion it is also aggravated by remaining in one position for a long time and is often particularly noticeable first thing in the morning. While the pain is not markedly

episodic it does tend to vary to some extent and often appears to be affected by the weather

On examination there is usually slight limitation of lumbar movement with pain or discomfort at the extremes of all movements. Muscle spasm is not marked and there are no postural deformities or local tenderness. As has been pointed out, signs of root irritation or compression are occasionally present.

On radiological examination osteoarthritic changes in the lumbar intervertebral joints can usually be detected. There is, however no constant relationship between the severity of the symptoms and the degree of radiological change, slight discomfort may be associated with gross changes and vice versa.

After middle age osteoarthritis is one of the most common causes of low back pain The symptoms produced and the clinical and radiological findings are usually sufficiently distinctive to prevent this condition being confused with a disc lesion. It should be remembered however that the presence of arthritic changes does not preclude the possibility of the existence of a disc lesion, indeed the two conditions fairly often co-exist.

5 *INTRASPINAL NEOPLASMS*

The major symptoms of intraspinal neoplasms are produced by interference with the spinal cord or the nerve roots in their intraspinal course It is true that when such tumours occur in the lumbar region they are associated with low back pain Only in certain types of tumours, however is low back pain a presenting or even a prominent symptom.

Any of the extradural tumours, which comprise some 20 per cent. of all intraspinal tumours may produce symptoms referred to the low back before the symptoms of root involvement become obvious. Of these extradural tumours, growths arising from bone and invading the spinal canal, growths which account for 10 per cent. of all intraspinal tumours, almost invariably produce low back pain as a presenting symptom

Patients suffering from low back pain caused by an intraspinal tumour and *unaccompanied by root symptoms* may present a difficult diagnostic problem The usual clinical findings are local pain some muscle spasm and some limitation of movement.

Radiographs usually reveal the presence of a tumour which arises from the vertebra and in this type of growth the diagnosis is based on the radiological findings Other types of extradural tumours are only revealed by a myelogram, an investigation which is not indicated unless there is clear clinical evidence to suggest a tumour

With the exception of growths arising from the bony vertebrae intraspinal tumours are rarely *associated with low back pain* alone and even more rarely diagnosed while in this stage. Such a neoplasm may simulate a disc lesion very closely

6 LOW BACK STRAINS ASSOCIATED WITH PREGNANCY

During the latter half of pregnancy there is a generalised softening of all the fibrous structures in the low back and in the pelvis These changes are associated with a loss of elasticity and a stretching of the intervertebral and lumbo sacral ligaments and are complicated by very considerable increase in the mechanical strains imposed on the low back this increase being produced by the presence of a gravid uterus. After parturition some months elapse before the ligaments regain their normal length and elasticity and during this time low back symptoms may appear or persist

During the latter stages of pregnancy a certain amount of low back pain is common This is produced in part by the ligamentous stretching and in part by the increased mechanical demands on the lumbo-sacral region On examination at this stage some muscle spasm and some pain at the extremes of movement are the usual findings but the clinical picture is of course, complicated by the pregnancy and is modified in the later stages by the limitation of all movements due to a gravid uterus nearing term

After parturition the patient may complain of persistent low back pain or low back pain may appear for the first time On examination there is some muscle spasm and some pain at the extremes of lumbar movement Occasionally an increased range of movement at the sacro-iliac joints may be detectable on clinical examination.

The low back strains associated with pregnancy do not produce any interference with root function and are not associated with symptoms referred to the legs

Radiological examination of the lumbar spine shows no abnormality

It should be remembered that disc lesions are particularly liable to occur during pregnancy probably because of softening of the annulus fibrosus Moreover lesions previously present tend to deteriorate, partly because of this softening and partly because of increased mechanical strain Nuclear retropulsion is common and may be massive, and most of the so-called maternal obstetrical palsies previously attributed to pressure by the foetal head are in fact produced by interference with root function associated with a disc lesion and a large nuclear retropulsion. It is very important therefore that these lesions should be detected as early as possible preferably before nuclear retropulsion has occurred so that the danger of a massive retropulsion with associated root symptoms may if possible be averted by treatment. For this reason every effort should be made to decide whether low back pain occurring during the latter stages of pregnancy or soon after parturition is due to ligamentous strain or to a lesion of one of the lower lumbar intervertebral discs

7 INFLAMMATORY LESIONS OF THE LUMBAR SPINE

Inflammatory lesions of the lumbar spine due to a focus of infection in the bony vertebrae themselves may be divided into two broad groups—non tuberculous and tuberculous. Both groups may be associated with root symptoms and for this reason have been discussed already in a previous section Root involvement is,

however unusual and in most cases the symptoms produced by these conditions are confined to the low back. The more important features of these infections may be reiterated.

(a) Non-tuberculous Infection (Osteomyelitis)

Osteomyelitis of a lumbar vertebra, like osteomyelitis elsewhere, usually takes the form of an acute fulminating staphylococcal infection and spreads from a focus somewhere in the bone. In the lumbar spine the usual site of the primary focus is in the vertebral body itself.

The patient complains of severe pain deep in the lumbar region, this pain being aggravated by movement or by exertion but not being relieved by rest. The pain is usually severe and incapacitating and may be of fairly dramatic onset.

On examination there is local tenderness over the affected vertebra marked muscle spasm and limitation of all spinal movements. Pyrexia, a raised white cell count, a raised sedimentation rate and the other symptoms and signs associated with an acute infection are present

Radiographs show bony changes around the site of infection but these changes may not become visible for between seven and twenty-one days after the onset of the infection.

An acute osteomyelitis of a lumbar vertebra might in its early stages just possibly be confused with an acute disc lesion The general signs of infection, the clinical findings and later the radiographs should, however reveal the true nature of the condition

(b) Tuberculosis of the Lumbar Spine:

A tuberculous infection of the lumbar spine is more insidious in its onset and course than the much rarer infection with a pyogenic organism.

The patient complains of dull aching pain in the low back, this pain being aggravated by exertion but not relieved by rest.

On examination there is localised tenderness over the affected vertebra, marked rigidity of the lumbar muscles and an almost complete loss of all lumbar movements. There are usually some general signs of infection even in the early stages, the most reliable being a slight evening rise of temperature and a raised sedimentation rate.

Radiographs first show rarefaction and later destruction of bone in the region of the tuberculous focus, these changes becoming more marked as the disease progresses. Narrowing of an intervertebral space may be the presenting radiological sign of a tuberculous infection.

Tuberculosis of the lumbar spine should not be confused with a disc lesion as the clinical findings the signs of infection and the radiographic changes provide ample evidence of the true nature of the condition

8 INFECTIONS OF THE SACRO-ILIAC JOINTS

A chronic infective arthritis of one or other of the sacro-iliac joints is by no means rare Tuberculosis is the most usual cause of such an infection but chronic non tuberculous infective arthritis is probably less rare than has been supposed.

(a) Sacro-iliac Tuberculous Arthritis

Tuberculosis of the sacro-iliac joint is in most instances an extremely chronic and slowly progressive condition Although in some patients abscess formation may occur within a few months of infection it is not unusual for symptoms to be present for months or even years before the joint changes become obvious.

A patient with a sacro-iliac tuberculosis complains of pain accurately localised to the infected joint. The pain is made worse by exertion and sharply aggravated by movements of the joint.

On examination tenderness is present over the affected joint and symptoms are accurately localised to this region. Some spasm of the lumbar muscles is usually present on the affected side and lumbar movements, particularly rotation are limited and cause pain in the affected joint If an abscess is present and is pointing posteriorly it is usually palpable and may even be visible. Some general signs of infection may be present a slight evening temperature and a raised sedimentation rate being the most constant.

Radiological examination of the sacro iliac joint may show rarefaction or even bone destruction in the region of the affected joint These signs are not reliable in the early stages, however and may not become visible until the condition has been present for many months. In any circumstances the sacro-iliacs are such irregular joints that it is not easy to obtain strictly comparable views of the two sides and to detect minor differences in bone texture by this means

Sacro-iliac tuberculosis is one of the less unusual causes of low back pain It is, however usually possible to differentiate between this condition and a disc lesion even in the early stages of the joint infection.

(b) Non-tuberculous Sacro-Iliac Arthritis

Some of the chronic infections of the sacro iliac joints are non-tuberculous in origin being caused by other pyogenic organisms

The course of these infections is extremely similar to that of tuberculous arthritis and the clinical manifestations are the same. The radiological appearance is also similar to tuberculosis although sometimes sclerosis rather than rarefaction is the outstanding feature.

As with tuberculous arthritis the differential diagnosis with respect to a disc lesion does not usually present undue difficulties.

9 SPONDYLITIS ANKYLOPOETICA

The predominant feature of spondylitis ankylopoetica of the Strumpell Marie type in its early stages is low back pain Later other features of the condition become more obvious and as has been pointed out sciatic pain is not uncommon. Pain in the lumbo-sacral region is, however a presenting, and for some time the only symptom

Patients with commencing spondylitis ankylopoetica are usually in their early twenties and complain of a dull aching pain in the low back. The pain is constant, not relieved by rest and not materially aggravated by exertion

On examination some limitation of all movements of the lumbar spine is often the only positive clinical finding. At this stage there may be no other clinical evidence of the condition although an examination of the blood usually shows some rise in the sedimentation rate

Radiological examination of the lumbar spine may at this stage be completely negative. The first changes to appear are usually in the sacro iliac joints but these do not occur for some months after the onset of symptoms

Early spondylitis ankylopoetica is not an obvious condition and the diagnosis is often missed until the disease has become well-established Even in the early stages, however the symptoms and clinical findings do not exactly simulate those of a disc lesion

10 SPONDYLITIS

Spondylitis is a term applied to a rather vague group of conditions characterised by changes in and around the intervertebral articulations These changes are not typically those of a degenerative arthritis nor are they characterised by the steadily progressive bone formation produced by ankylosing spondylitis

For the purposes of classification spondylitis may be divided into two types, the infective and the non infective, or rheumatic. Both types may be associated with pain referred to the lumbar region although in most instances symptoms occur in the whole spine

(a) Infective Spondylitis

Certain general infections, notably gonococcal infection are sometimes associated with pain and stiffness in the spine. These symptoms appear to be due to a chronic arthritis or synovitis of the intervertebral joints.

Symptoms are not usually confined to any single region of the spine although the dorsal area is often the site of the most severe discomfort.

Patients with this type of spondylitis complain of pain and stiffness of the back, these symptoms usually being widely referred to the whole spine

On examination there is some generalised limitation and pain on movement. There may be slight muscle spasm but there are no postural deformities and no marked local tenderness Other evidence of the primary infection is usually present both on clinical examination and on blood investigation

Radiographs of the spine do not show any obvious changes in the early stages. Later good oblique views may show some narrowing of and arthritic changes in the posterior articulations. In the very late stages when the condition has been present for many years generalised joint changes very similar to those of degenerative arthritis may appear

An infective spondylitis is an unusual cause of low back pain and should not be confused with a disc lesion The symptoms are more widespread and there is usually evidence of the primary infection

(b) Non-Infective (Rheumatic) Spondylitis:

Polyarticular arthritis associated with proliferative periarticular changes the so-called rheumatic type of arthritis, quite commonly involves the spinal column in association with joint lesions elsewhere in the body

The spinal changes take the form of chronic synovitis with periarticular thickening and are associated with pain and limitation of movement. Such patients complain of pain in the back this pain usually being quite widespread Examination shows some limitation of and pain on spinal movement but *these findings are often* masked by the more obvious findings associated with the other involved joints

Rheumatic spondylitis is one of the rarer causes of pain in the lumbar region It probably never occurs as an isolated condition but only in association with other joint lesions and is unlikely to simulate or be confused with a disc lesion

11 OSTEITIS DEFORMANS (PAGET'S DISEASE) OF THE LUMBAR SPINE

Osteitis deformans commonly affects the vertebral column where it may be localised to the lumbar region In most instances the condition is not confined to the spine but occurs in association with lesions elsewhere in the skeleton As has been pointed out, root involvement is not uncommon in the later stages when the lumbar spine is affected

Patients with osteitis deformans in the lumbar region complain of a deep boring pain in the low back this pain being constant and unaffected by exertion or rest. In most patients lesions elsewhere in the skeleton are associated with local symptoms and root involvement may be indicated by pain referred to the legs

On examination there may be slight muscle spasm and limitation of all lumbar movements and the affected vertebrae are usually tender on heavy percussion. Lesions elsewhere are associated with local findings in the affected areas.

Radiological examination shows the changes typical of the condition in the affected vertebrae and elsewhere

Osteitis deformans of the lumbar spine may produce a constant low back pain unaccompanied by any very definite clinical findings While the diagnosis can rarely be made with certainty on clinical evidence alone the true nature of the condition is usually revealed by radiographs

12. SENILE OSTEOPOROSIS OF THE LUMBAR SPINE

Senile osteoporosis of the spine is a condition in which decalcification is associated with slight progressive wedging of the vertebral bodies. The whole spine may be equally affected or one region may be the site of the most marked changes. In the majority of patients symptoms are referred to the dorsal spine the changes being most marked in this area. From time to time, however the most severe symptoms are referred to the lumbar region

Patients with this condition are usually of advanced age and complain of pain in the low back this pain being made worse by standing or by exertion and slightly relieved by rest.

On examination such patients usually have considerable limitation of all spinal movements but this stiffness is not necessarily more marked than is usual in persons of advanced age There may be some local spasm of the lumbar muscles and some deep tenderness over the lumbar spine

Radiographs show marked osteoporosis of the lumbar vertebrae, possibly associated with some wedging of the vertebral bodies.

Senile osteoporosis affecting the lumbar spine is one of the more unusual causes of low back pain. The diagnosis is based on the age of the patient and on the X ray changes and it is unlikely that this condition could be confused with a disc lesion

13 FIBROSITIS (FIBROMYOSITIS) OF THE LUMBAR MUSCLES ('LUMBAGO')

The aetiology pathology and indeed even the existence of so-called fibrositis or fibromyositis is uncertain. Classically this condition is characterised by local pain and tenderness in a muscle or muscle group The pain is often severe and of sudden even dramatic, onset. In the acute phases spasm of the affected muscles is marked and the condition may be completely incapacitating.

The underlying cause of fibrositis is unknown although attacks are often attributed to exposure to cold or wet No local pathological changes in the affected muscles have ever been observed although the condition is believed to be due to oedema or mild inflammatory changes somewhere in the muscles themselves. The spinal muscles are the usual site for fibrositis although the condition has been described elsewhere and the muscles of the lower cervical, the upper dorsal and the lumbar region are most commonly affected

In the lumbar region the usual history is of incapacitating pain of sudden onset. The pain is severe and may be completely crippling in the acute stages. The pain tends to decrease during the course of a few days and is relieved by heat and rest

On examination in the acute stages there is severe spasm of the lumbar muscles with limitation of all movements, flexion and extension being most affected The muscles may be tender on palpation and in some patients it may be possible to elicit points of acute local tenderness and muscle spasm the so-called fibrositic nodules. Postural scoliosis is not uncommon and quite often there is some limitation of straight leg raising.

The symptoms and clinical findings in acute fibrositis of the lumbar muscles, the so-called lumbago are extremely similar to those of a disc lesion in the acute stage In fact many disc lesions are diagnosed as lumbago and treated by physiotherapy for some time before the true nature of the condition is suspected It should be remembered that many observers do not believe that fibrositis exists as a local condition but consider that the pain and spasm are caused by some central lesion involving the nerve supply to the affected muscles. Whether this is completely true or not there can be no doubt that fibrositis of the lumbar muscles, the so-called lumbago is much less common than was formerly believed The

diagnosis should only be made with the greatest caution after the possibility of the presence of a lumbar disc lesion has been considered carefully

14 VERTEBRAL OSTEOARTHROPATHY (CHARCOT'S DISEASE OF THE SPINE)

Bony changes in the vertebral bodies produced by syphilitic infection in the tertiary stage are one of the rarer causes of low back pain

One or several of the lower lumbar vertebrae may be affected In the earlier stages the changes resemble those seen in osteoarthritis but they progress rapidly and are associated with exuberant new bone formation.

The diagnosis of this condition depends on the characteristic radiological appearance and on the associated signs and symptoms of syphilis

15 LOW BACK PAIN REFERRED FROM PELVIC VISCERA

It was formerly considered that lesions of the pelvic viscera could produce referred low back pain and it was frequently stated that this pelvic backache was often indistinguishable from sciatic backache.[1]

It is true that some diseases of the pelvic viscera, particularly in the female, are associated with sensations of pain or discomfort which are vaguely referred to the low back. These sensations do not appear to be true pain however but are variously described as dragging or crushing or bearing down Such sensations are not associated with any abnormality on clinical examination of the low back

In the author's opinion it is extremely rare for true low back pain to be due to a gynaecological or other pelvic lesion. It is most unusual to see patients in whom such lesions have been missed because symptoms have been attributed to some disorder of the low back. On the other hand, many patients with low back lesions, in particular with lesions of the lower lumbar intervertebral discs, bear an abdominal scar dating from some operative procedure performed in a fruitless attempt to relieve their symptoms

LESIONS ASSOCIATED WITH SCIATIC PAIN

It has been pointed out that a lumbar disc lesion may produce the symptoms of root irritation or compression unaccompanied by any low back symptoms at all. In these circumstances, the differential diagnosis involves consideration of the commoner conditions which affect the sciatic nerve.

These are classified in Table VII and may now briefly be considered in detail. It will be noted that many may also be associated with low back pain and have therefore been dealt with already in a previous section

The classification has been made on an anatomical basis depending on the point at which the nerve is affected

[1] Jones, Robert, & Lovat, R. W (1923) *Orthopaedic surgery* 328 329 Oxford Medical Publications.

1 INTRASPINAL LESIONS

The first group are those affecting the roots in their intraspinal course either before or after they have traversed the theca.

(a) Arachnoiditis :

The chronic types of arachnoiditis may produce root irritation and referred pain

One type, a localised and chronic inflammatory lesion is syphilitic. This is usually associated with other syphilitic lesions in the nervous system and elsewhere in the body and the presence of a specific infection is shown by a positive blood or cerebrospinal fluid Wassermann reaction.

The second type the so-called meningitis serosa circumscripta is a rare lesion of unknown aetiology Sometimes following a spinal injury it consists of chronic thickening of a comparatively small area of the spinal meninges. In its early stages symptoms of root irritation are predominant, all the roots in contact with the affected area being involved Later increased thickening produces symptoms of spinal compression.

(b) Intraspinal Tumours

Intraspinal tumours of various types involve the roots of the sciatic nerve in their intraspinal course The nature and symptoms of these tumours have been discussed.

(c) Osteoarthritic Lipping

It has been pointed out that occasionally osteoarthritic lipping of the posterior margin of the vertebral bodies may be in contact with and produce irritation of the roots in their extrathecal course close to their exit from the theca.

(d) Tuberculous Abscess

The role of the tuberculous abscess in the production of root irritation has been discussed.

(e) Osteomyelitic Abscess :

An intraspinal abscess associated with osteomyelitis of the vertebral body may occasionally cause root irritation. This condition also has been discussed.

(f) Hypertrophy of Ligamentum Flavum

Some authorities consider that pressure from a hypertrophied ligamentum flavum may be a cause of root irritation. *In the author's view* this hypertrophy is one of the secondary effects of a disc lesion and does not occur as a primary *condition* When hypertrophy of the ligamentum is present in association with nuclear retropulsion particularly if the protrusion is pararhyzal in site, a root may be compressed between the displaced nuclear tissue and the lateral free edge of

the hypertrophied ligament This is particularly likely to happen in the trefoil sh type of canal and has been referred to in the section dealing with the patholo changes associated with disc lesions.

Hypertrophy of the ligamentum flavum occurring as one of the secon effects of an intervertebral disc lesion may therefore in certain circumstance an important contributory factor in the production of root compression condition is, however secondary to and associated with a disc lesion

(g) Spondylolisthesis

The step in the anterior wall of the spinal canal produced by for displacement of a vertebral body in relation to the body below may involve roots in their extrathecal intraspinal course. These roots may be kinked ove adherent to this step and root irritation so produced may cause sciatic sympt

TABLE VII

LESIONS ASSOCIATED WITH SCIATIC PAIN

I. Intraspinal pressure or irritation	(*a*) Lumbar disc lesions. (*b*) Arachnoiditis { Syphilitic. / Non-syphilitic (*c*) Intraspinal tumours. (*d*) Osteoarthritic lipping. (*e*) Tuberculous abscess. (*f*) Osteomyelitic abscess. (*g*) Hypertrophy of Ligamentum Flavun (*h*) Spondylolisthesis. (*i*) Developmental narrowing of luml canal. (*j*) Malformation of lumbar roots a sheaths.
II Pressure or irritation at intervertebral foramen	Chronic arthritis of posterior intervertebı joints. Spondylitis. Spondylitis ankylopoetica. Paget s disease Spondylolisthesis.
III. Pressure or irritation in course of nerve	Inflammation or malignant disease pelvic viscera Osteomyelitis or neoplasms of bony pelv Pelvic aneurysm. Arthritis of the hip joint. Injury to nerve itself.
IV Disorders of nerve trunk	Primary sciatica. Peripheral neuritis { Chronic infectio / Arsenic. / Alcohol. / Lead / Herpes zoster / Diabetes. / Vitamin deficien Tumours of nerve sheath.

(h) Developmental Narrowing of Spinal Canal

A developmental stricture of the lumbar canal may be associated with root irritation and sciatic symptoms

(i) Malformation of Lumbar Roots and Sheaths:

Developmental malformations of the lower lumbar roots and their sheaths may be associated with the symptoms of root irritation

2. FORAMINAL LESIONS

The second group of lesions are those causing compression or irritation of the roots as they pass through the intervertebral foramina. Arthritis of the posterior intervertebral joints, either local or associated with a general spinal arthritis, spondylolisthesis, spondylitis or Paget's disease, may be associated with root involvement at the foramina, and all these conditions have been discussed.

Symptoms may be produced by partial occlusion of the foramen, due to peri articular fibrosis and oedema. Because the lumbar foramina decrease in size from above downwards while the size of the lumbar roots increases, the lower roots would be the most liable to be affected by such a process.

In the author's view foraminal irritation is more often due to root adherence following local oedema and fibrosis than to root compression

3 LESIONS IN THE COURSE OF THE NERVE

Pressure on or irritation of the sciatic nerve trunk itself may occur at varying points in its course This may produce pain felt in the distribution of the nerve or sensory motor or reflex changes, depending on the nature and severity of nerve involvement.

In the pelvis the sciatic nerve may be affected by malignant or inflammatory disease of the pelvic viscera, by osteomyelitis or neoplasm of the bony pelvis (Plate 18) or rarely by a pelvic aneurysm The nerve may be compressed by a space-occupying lesion although this probably occurs less often than has been supposed. It may also be directly involved in inflammatory lesions or neoplasms of tissues or organs with which it is in close contact.

In the gluteal region the sciatic nerve while not in direct contact with the posterior surface of the capsule, is close enough to the hip joint to make it possible that it may be affected by the periarticular changes associated with chronic arthritis. Although sciatic pain is one of the text book complications of chronic arthritis of the hip, in practice true sciatica is very rarely found in association with this condition.

The sciatic nerve may be injured in any part of its course In the pelvis the nerve is so protected that it is only involved in gunshot or penetrating wounds. In the gluteal region it is more exposed and may be contused or crushed. Similarly but less commonly the nerve may be injured in the thigh The effects of injury depend on its nature and severity and vary between the extremes of causalgia on one hand and complete paralysis on the other



PLATE 18

Neoplasm of pelvis associated with sciatica

This patient developed severe monoradicular sciatica associated with some discomfort in the low back. The pain did not respond to any form of conservative treatment and finally laminectomy was carried out. No lesion was found. Symptoms persisted and became polyradicular pain being associated with sensory and motor changes. Some months after operation radiographs showed a neoplasm of the pelvis, all the previous radiographs having been normal

(h) Developmental Narrowing of Spinal Canal

A developmental stricture of the lumbar canal may be associated with root irritation and sciatic symptoms.

(i) Malformation of Lumbar Roots and Sheaths:

Developmental malformations of the lower lumbar roots and their sheaths may be associated with the symptoms of root irritation.

2. FORAMINAL LESIONS

The second group of lesions are those causing compression or irritation of the roots as they pass through the intervertebral foramina Arthritis of the posterior intervertebral joints, either local or associated with a general spinal arthritis, spondylolisthesis, spondylitis or Paget's disease, may be associated with root involvement at the foramina, and all these conditions have been discussed

Symptoms may be produced by partial occlusion of the foramen due to peri articular fibrosis and oedema Because the lumbar foramina decrease in size from above downwards while the size of the lumbar roots increases, the lower roots would be the most liable to be affected by such a process.

In the author's view foraminal irritation is more often due to root adherence following local oedema and fibrosis than to root compression.

3 LESIONS IN THE COURSE OF THE NERVE

Pressure on or irritation of the sciatic nerve trunk itself may occur at varying points in its course This may produce pain felt in the distribution of the nerve or sensory motor or reflex changes, depending on the nature and severity of nerve involvement.

In the pelvis the sciatic nerve may be affected by malignant or inflammatory disease of the pelvic viscera by osteomyelitis or neoplasm of the bony pelvis (Plate 18) or rarely by a pelvic aneurysm The nerve may be compressed by a space-occupying lesion although this probably occurs less often than has been supposed It may also be directly involved in inflammatory lesions or neoplasms of tissues or organs with which it is in close contact.

In the gluteal region the sciatic nerve, while not in direct contact with the posterior surface of the capsule is close enough to the hip joint to make it possible that it may be affected by the periarticular changes associated with chronic arthritis. Although sciatic pain is one of the text book complications of chronic arthritis of the hip in practice true sciatica is very rarely found in association with this condition

The sciatic nerve may be injured in any part of its course In the pelvis the nerve is so protected that it is only involved in gunshot or penetrating wounds. In the gluteal region it is more exposed and may be contused or crushed Similarly but less commonly the nerve may be injured in the thigh. The effects of injury depend on its nature and severity and vary between the extremes of causalgia on one hand and complete paralysis on the other



PLATE 18

Neoplasm of pelvis associated with sciatica

This patient developed severe monoradicular sciatica associated with some discomfort in the low back. The pain did not respond to any form of conservative treatment and finally laminectomy was carried out. No lesion was found. Symptoms persisted and became polyradicular pain being associated with sensory and motor changes. Some months after operation radiographs showed a neoplasm of the pelvis, all the previous radiographs having been normal.

(h) Developmental Narrowing of Spinal Canal :

A developmental stricture of the lumbar canal may be associated with root irritation and sciatic symptoms.

(i) Malformation of Lumbar Roots and Sheaths.

Developmental malformations of the lower lumbar roots and their sheaths may be associated with the symptoms of root irritation.

2. FORAMINAL LESIONS

The second group of lesions are those causing compression or irritation of the roots as they pass through the intervertebral foramina Arthritis of the posterior intervertebral joints, either local or associated with a general spinal arthritis, spondylolisthesis, spondylitis or Paget's disease, may be associated with root involvement at the foramina, and all these conditions have been discussed

Symptoms may be produced by partial occlusion of the foramen, due to peri articular fibrosis and oedema. Because the lumbar foramina decrease in size from above downwards while the size of the lumbar roots increases, the lower roots would be the most liable to be affected by such a process.

In the author's view foraminal irritation is more often due to root adherence following local oedema and fibrosis than to root compression.

3 LESIONS IN THE COURSE OF THE NERVE

Pressure on or irritation of the sciatic nerve trunk itself may occur at varying points in its course This may produce pain felt in the distribution of the nerve or sensory motor or reflex changes, depending on the nature and severity of nerve involvement.

In the pelvis the sciatic nerve may be affected by malignant or inflammatory disease of the pelvic viscera by osteomyelitis or neoplasm of the bony pelvis (Plate 18) or rarely by a pelvic aneurysm The nerve may be compressed by a space-occupying lesion although this probably occurs less often than has been supposed. It may also be directly involved in inflammatory lesions or neoplasms of tissues or organs with which it is in close contact.

In the gluteal region the sciatic nerve while not in direct contact with the posterior surface of the capsule, is close enough to the hip joint to make it possible that it may be affected by the periarticular changes associated with chronic arthritis. Although sciatic pain is one of the text book complications of chronic arthritis of the hip in practice true sciatica is very rarely found in association with this condition.

The sciatic nerve may be injured in any part of its course In the pelvis the nerve is so protected that it is only involved in gunshot or penetrating wounds. In the gluteal region it is more exposed and may be contused or crushed Similarly but less commonly the nerve may be injured in the thigh The effects of injury depend on its nature and severity and vary between the extremes of causalgia on one hand and complete paralysis on the other

presumably the site of whatever pathological changes are present symptoms and signs should be multiradicular rather than monoradicular and should tend to be those of irritation rather than of severe compression The existence of such a condition can only be a matter of assumption however as local exploration of the sciatic nerve is both unjustifiable and inconclusive and opportunities for microscopic examination of the nerve in such patients are, happily almost unknown

(b) Peripheral Neuritis

The sciatic nerve may be involved in various forms of peripheral neuritis. Such a neuritis may be due to several causes, the commonest of which are probably chronic infection chemical poisons such as arsenic, alcohol or lead Herpes Zoster diabetes or vitamin deficiency

Pain is not usually a feature of the condition and one nerve is rarely affected alone Motor symptoms in the form of muscle cramp muscle weakness and paralysis of a lower motor neuron type are commonly present. Sensory impairment, starting with tingling and a feeling of pins and needles and advancing towards complete loss of both superficial and deep sensation is also usual Tendon reflexes are first exaggerated and later disappear

The widespread distribution and the comparative absence of pain makes it possible to distinguish between peripheral neuritis and other lesions of the sciatic nerve.

(c) Tumours of Nerve Sheath (Neuromata)

A solitary tumour of the sciatic nerve, such as neuronoma, neurilemmoma or neurofibroma, may produce symptoms

Such a tumour acts mainly by mechanical pressure causing either nerve irritation or compression. Irritation is associated with pain felt in the distribution of the nerve, compression with impairment of sensory motor or reflex function.

In the early stages the whole nerve is not necessarily equally affected and symptoms may be partially monoradicular Symptoms are, however progressive and unremitting.

In the early stages a local nerve tumour may pass undetected even when it is causing quite severe symptoms Ultimately however its presence is revealed by local tenderness, by a palpable swelling or occasionally by surgical exploration

4 LOCAL LESIONS OF THE SCIATIC NERVE

The sciatic nerve trunk or roots may be affected by various local conditions, all of which are associated with symptoms of disturbance of function or irritation.

(a) 'Primary' Sciatica (Sciatic Neuritis)

This condition was regarded formerly as by far the most usual cause of sciatic pain and was frequently diagnosed Although its true nature was regarded as doubtful, focal sepsis being considered the most probable aetiological factor the pathological changes were described as a swelling of the interstitial tissues in the nerve roots or trunk. This swelling distended the nerve and produced compression of the nerve fibres within the sheath. Since sciatica is not a fatal disease, these alleged changes could not be studied by the morbid anatomist and proof of their existence depended on the observations of the various surgeons who reported that they had explored the sciatic nerve in patients suffering from sciatica and had found its trunk swollen, hyperaemic and oedematous. It should be noted that many other surgeons reported that they had signally failed to confirm these findings in patients with exactly similar conditions.

Various peripheral symptoms and signs were reputed to be typically associated with primary sciatica.

Pain in the distribution of the sciatic nerve was the predominating feature. This pain was described as being episodic in character attacks of intense pain of lancinating nature being separated by periods in which the discomfort was said to be in the nature of a dull ache. Patients were also said to complain of a tingling feeling in the cutaneous distribution of the nerve.

On examination of the legs, nerve irritability was indicated by pain on raising the straight leg. Tenderness over the nerve trunk was said to be a marked and characteristic feature of the condition, and the muscles supplied by the nerve were also tender Slight disturbance of sensation was usual, reflex changes might occur but gross muscle weakness was said to be rare

It is significant that most of the classical descriptions of this condition state that it is associated with low back symptoms in the form of pain, limitation of movement and postural scoliosis. There can be little doubt that the vast majority of patients once regarded as suffering from primary sciatica had in fact a lesion of one of the lower lumbar intervertebral discs. This view is greatly strengthened by the fact that, although a great multitude of therapeutic measures were suggested and practised all the most reliable authorities appeared to agree that the only really effective treatment for the condition was complete rest in bed for a long period

In the author's view a true primary sciatica produced by interstitial changes in the nerve or its roots must be a rare condition Its presence is to be suspected in patients suffering from fairly severe and continuous pain felt in the cutaneous distribution of the nerve and unassociated with any low back symptoms if on examination a marked tenderness along the course of the nerve is a prominent finding and if the low back appears clinically normal. Since the nerve trunk is

presumably the site of whatever pathological changes are present symptoms and signs should be multiradicular rather than monoradicular and should tend to be those of irritation rather than of severe compression The existence of such a condition can only be a matter of assumption however as local exploration of the sciatic nerve is both unjustifiable and inconclusive and opportunities for micro scopic examination of the nerve in such patients are happily almost unknown

(b) Peripheral Neuritis

The sciatic nerve may be involved in various forms of peripheral neuritis Such a neuritis may be due to several causes, the commonest of which are probably chronic infection chemical poisons such as arsenic, alcohol or lead Herpes Zoster diabetes or vitamin deficiency

Pain is not usually a feature of the condition and one nerve is rarely affected alone. Motor symptoms in the form of muscle cramp muscle weakness and paralysis of a lower motor neuron type are commonly present Sensory impairment, starting with tingling and a feeling of pins and needles and advancing towards complete loss of both superficial and deep sensation is also usual Tendon reflexes are first exaggerated and later disappear

The widespread distribution and the comparative absence of pain makes it possible to distinguish between peripheral neuritis and other lesions of the sciatic nerve.

(c) Tumours of Nerve Sheath (Neuromata)

A solitary tumour of the sciatic nerve, such as neuronoma neurilemmoma or neurofibroma, may produce symptoms.

Such a tumour acts mainly by mechanical pressure causing either nerve irritation or compression. Irritation is associated with pain felt in the distribution of the nerve compression with impairment of sensory motor or reflex function

In the early stages the whole nerve is not necessarily equally affected and symptoms may be partially monoradicular Symptoms are, however progressive and unremitting.

In the early stages a local nerve tumour may pass undetected, even when it is causing quite severe symptoms Ultimately however its presence is revealed by local tenderness, by a palpable swelling or occasionally by surgical exploration

CHAPTER XII

THE CONSERVATIVE TREATMENT OF LUMBAR DISC LESIONS

ONCE nuclear degeneration whether *accompanied by annular rupture* and nuclear retropulsion or not, has taken place the disc affected cannot be restored entirely to normal by any form of treatment. At the same time under favourable circumstances a process of healing takes place and when this is complete the symptoms associated with an active disc lesion disappear

The basis of any rational and effective treatment of a lumbar disc lesion is the establishment of the most favourable possible conditions for natural healing. While it is sometimes necessary to expose and remove the abnormal nucleus to achieve such conditions this is only so in a comparatively small proportion of all patients and the vast majority recover with effective conservative treatment.

THE PRINCIPLES ON WHICH CONSERVATIVE TREATMENT IS BASED

Early nuclear degeneration implies a softening and breaking up of the normal nucleus pulposus, this process spreading to and involving the posterior part of the annulus fibrosus. At this stage if movement between the vertebral bodies is prevented and if the degenerate tissue is protected from all stresses and strains healing takes place by a combination of dehydration and fibrosis The newly-formed fibrous tissue must be protected until it becomes completely organised and firm a process which takes many months Once mature, however such tissue will stand up to any reasonable strains and may wear almost indefinitely

If the stage of annular rupture and retropulsion of nuclear fragments has been reached these displaced sequestra may produce symptoms in two ways An incompletely extruded fragment may become impacted between the posterior rims of the vertebral bodies while an extruded sequestrum may cause pressure symptoms by involving either a root in its extrathecal course or less commonly the cauda equina itself It is by no means always necessary to remove such sequestra surgically *If the spine is immobilised they shrivel and fibrose* and since their water content is between 70 and 80 per cent. they may ultimately shrink to between one third and one fifth of their original size. This reduction in bulk is usually sufficient to relieve pressure symptoms or to allow an impacted fragment to slip back into the central concavity between the vertebral bodies.

In the late stages of a disc lesion the chances of the formation of a firm fibrous ankylosis of the damaged intervertebral joint are much more favourable *if this segment of the spine is immobilised and relieved of mechanical strains.*

It is therefore clear that the essential features of successful conservative treatment of a disc lesion at any stage are firstly the protection of the abnormal disc

from all strains and secondly the prevention of any movement between the contiguous vertebral bodies.

MEASURES EMPLOYED IN CONSERVATIVE TREATMENT

The two basic requirements of conservative treatment avoidance of strains which may fall on the damaged nucleus and the prevention of movement between the adjacent vertebrae, are achieved by two measures These, the two cardinal features of conservative treatment are rest and immobilisation of the lumbar spine.

Rest is a comprehensive term which may be applied to any of the restrictions on activity employed in the management of patients with lumbar disc lesions. At one extreme is complete rest in bed the patient being nursed supine and not allowed to sit up or even to raise the head At the other rest may be interpreted as meaning a modification of the patient s activities or even a simple avoidance of flexion strains on the spine. Between these two extremes lie all gradations of decrease in activity and these restrictions are imposed in accordance with the state of the lesion, the patient s symptoms and the response to treatment.

Immobilisation of the lumbar spine is also achieved in many different ways, each having its advantages and disadvantages Complete bed rest alone greatly decreases lumbar movement and the specific avoidance of certain actions also helps. It is, however usually necessary to reinforce avoidance of activity whether complete or partial by actual splinting of the spine The plaster bed the hip spica, the plaster jacket and the lumbar corset each have their place and value

The specific application of these measures is most conveniently discussed in relation to the patient s symptoms, although these depend, of course on the nature and stage of the underlying disc lesion.

TREATMENT IN RELATION TO THE PATIENT'S SYMPTOMS

A single patient often runs the whole gamut of symptoms associated with a lumbar disc lesion and the treatment necessarily depends on the stage reached when advice is sought. More the periodicity so characteristic of these lesions may be responsible for a variation in symptoms if not from day to day at least from week to week This natural tendency to exacerbations and remissions must be taken into account not only when deciding on which measures are appropriate for any particular patient but also when assessing the effects of conservative treatment

While no such classification has any sound pathological basis it is convenient from the point of view of treatment to divide patients into three groups depending on whether their symptoms are acute sub-acute or chronic.

1 Patients with Acute Symptoms:

Immediately after annular rupture with associated nuclear retropulsion symptoms tend to be severe and incapacitating. Acute and crippling low back pain is probably due to locking of the affected intervertebral joint by the impaction of a nuclear sequestrum between the posterior rims of the adjacent vertebral bodies

Severe sciatica is caused by compression or stretching of a nerve root in its extra-thecal course by an extruded sequestrum Repetitions of these acute symptoms tend to occur with each recurrent retropulsion of a nuclear fragment or fragments.

In the acute phase the most effective measure is complete rest in bed This is at once the most valuable and the most abused form of treatment in the management of patients with acute symptoms produced by a lumbar disc lesion. Properly carried out, relief of symptoms is so constant that their persistence after the method has been given a fair trial can reasonably be regarded as an indication for operation Unfortunately however bed rest is far too often interpreted as meaning that the patient is confined to bed in a casual sort of way with no restriction of position and no prohibition on getting up for toilet purposes or for washing. Such treatment has practically no effect on the acute symptoms

To be effective bed rest should take the following form The patient should be nursed almost completely supine, only one small pillow being allowed beneath the head. The mattress should be fairly rigid and unyielding and if necessary fracture boards should be used to reinforce a mattress which is too soft. This position should be maintained constantly the patient not being allowed to get up or sit up for any purpose whatever This, of course, entails nursing attention as bed pans, washing and feeding means that the patient requires fairly constant care. For this reason this form of treatment is better carried out in a hospital or clinic than in the average home.

Quite often during the first 48 hours in bed the symptoms appear to become more severe and the patient is in considerable pain. During this time sedatives and analgesics must be exhibited and it is quite usual to find that pain can only be controlled by full doses of one of the morphine preparations The patient must be warned beforehand that this initial period of discomfort is usual. If this warning is omitted patients may become discouraged or yield to the temptation to get out of bed to stretch the back.

Once the initial period of exacerbation is past patients usually become more comfortable quite quickly Some simple sedative is necessary to ensure sleep at night, particularly as many people find it difficult to acquire the habit of sleeping on their back. As pain and discomfort decrease symptoms are easily controlled by one of the analgesic drugs.

The diet should be light and eating is made easier and digestion improved if the head of the bed is raised on low blocks The use of a reversible bed table with book clamps makes it possible to read in comfort

On the average, symptoms start to decrease within four or five days of the institution of complete bed rest and usually all pain has disappeared in between two and three weeks. It is important, however that bed rest should be continued until symptoms have been absent for some time, a good working rule being to keep the patient at rest half as long again as it takes for the symptoms to disappear It is also essential that a return to full activity should be carried out in gradual stages and that the lumbar spine should be protected during this time This phase of treatment will be discussed in a later section

If symptoms persist completely unabated for three weeks in spite of complete rest in bed it may be safely assumed that this form of treatment is not enough and other measures in particular operation must be considered

In the acute stage immobilisation of the lumbar spine as a measure of treatment takes second place to restriction of activity in the form of complete rest in bed

In exceptional circumstances when the patient has very cogent reasons for wishing to avoid being laid up an effort may be made to combine treatment with full activity This is done by immobilising the spine in a plaster jacket and allowing the continuation of a normal life While this measure, which will be discussed in detail in a later section is most valuable when applied to patients with sub-acute or chronic symptoms, it tends to be unsatisfactory and unreliable in its results in the presence of severe and acute symptoms Only too often the immediate relief is only partial and subsequent improvement slow or absent If possible, treatment by immobilisation in a plaster jacket without restriction of activity should be avoided in the acute phases of a disc lesion

Immobilisation of the lumbar spine may however be combined with complete rest in bed In these circumstances the spine may be splinted in one of three ways

(*a*) The simplest method is to combine complete rest in bed with traction on one or both legs With the foot of the bed raised on low blocks, skin traction using weights of five or six pounds is applied to one or both legs, the general management of the patient being otherwise exactly the same This method appears to be more popular in America than in this country Its main advantage seems to be that it prevents the patient turning on one side either deliberately or during sleep It is also true that it has a certain dramatic appeal and some psychological value, the patient invariably being convinced that the traction will help the disc to slip back into place. On the whole, however the results appear to be the same as those produced by complete bed rest and the application of traction adds to some extent to the patient s discomfort and to the problems associated with nursing

(*b*) The second method is to employ a plaster bed in the form of a posterior plaster shell. This has the advantage of ensuring absolute immobilisation of the lumbar spine and is a valuable addition to complete bed rest in some circumstances It is particularly useful for patients who have not responded to partial rest in bed or for those who tend to be very restless so that they cannot easily be persuaded to maintain a supine position

The construction of a posterior plaster shell is simple. The patient lies prone on a suitable table a pillow being placed below the tibiae and a small sandbag under the head the cervical spine being in the neutral position A double layer of ordinary cotton wool is applied to the patient s neck back and legs as far as the knees. Using broadsheet plaster or plaster slabs, a posterior shell extending from the neck to the knees is constructed The shell is moulded closely to the patient and extends about half way round the lower part of the thorax the lumbar region, the pelvis and the thighs In the region of the scapulae the shell does not extend lateralwards as free movement of the arms is permitted When the plaster has set, the shell, complete with its cotton wool lining, is lifted from the patient

A suitable aperture is cut in the bed pan area and the rough edges trimmed and bound When the plaster has dried it is placed on a bed, being supported by two wooden cradles which lift it some six inches so that a bed pan may be inserted between it and the mattress. The patient is then lifted into the shell, pillows being arranged so that the head and the legs below the knees are supported A pillow must also be inserted between the shell and the mattress in the region of the bed pan aperture, this latter being packed quite firmly so that pressure from its rim is avoided.

From the nursing point of view the management of a patient in such a shell is relatively simple, and after some initial discomfort symptoms usually disappear rapidly Provided the shell has been competently made so that its inner surface is smooth and provided the cotton wool padding is adequate, there is no undue pressure over the bony points and pressure changes in the skin do not occur

The patient is nursed in this shell until symptom-free. The minimum period of immobilisation should be about three weeks and if symptoms persist unchanged for about six weeks the question of operation should be considered. It is not necessary to move the patient from the plaster bed at any time during treatment Indeed, any such movement is undesirable. Changes in the skin due to pressure do not occur in a well fitting shell when the period of immobilisation is relatively short.

A patient who has been symptom free for some days is taken out of the shell and nursed supine for a further few days before beginning a gradual return to activity

(c) The third method, which may be employed when low back pain is associated with unilateral sciatica consists of immobilisation in a single hip spica Those who advocate this measure point out that such a spica not only immobilises the lumbar spine but also prevents any movement of or tension on the affected sciatic roots This form of immobilisation is in fact effective and if persisted with for a sufficiently long period it will ultimately relieve low back pain and sciatica due to a disc lesion in a very high proportion of patients. While it is a valuable measure of treatment when severe sciatic pain is present it has, however certain disadvantages and should in the author's opinion never be continued for more than a month or six weeks If the affected leg is immobilised for too long adhesions between the irritated root and the abnormal disc may form and organise. Moreover while prolonged immobilisation of the leg in a spica may be associated with a cessation of sciatic pain, the onset of motor and sensory changes may pass unnoticed under the plaster so that severe root compression with impairment of function may not be detected until irreversible changes have occurred Immobilisation in a hip spica is best regarded as a short-term measure applicable to patients with acute symptoms predominantly of severe sciatic pain Persistence of such symptoms after four weeks effective immobilisation indicates that other measures should be considered

A plaster jacket should not be used in conjunction with complete bed rest Such jackets inevitably tend to slip upwards a little when the patient lies down

and are least effective if a patient is confined to bed Morover since a cert amount of movement inside the jacket is inevitable in these circumstances comfort and pressure sores are quite commonly produced Such a jacket adds li to the efficacy of treatment by complete bed rest and is a source of consider discomfort to the patient

When as the result of conservative treatment the acute symptoms h subsided the patient must make a very gradual return to activity if the dar of a recurrence is to be avoided Bed rest is continued for about half as long ag as the time required for the disappearance of symptoms The patient is t allowed to get up for increasing periods each day wearing a lumbar co Provided progress is satisfactory the patient may then be regarded as hav passed into the sub-acute stage and is allowed to return gradually to normal the lumbar spine being suitably immobilised

2. Treatment of Patients with Sub-Acute Symptoms :

Not all patients with lumbar disc lesions have severe and incapacita symptoms, and even when this phase does occur it is usually transient Comm the symptoms produced by disc lesions while constant, trying and tending to exacerbated by exertion are not intense or crippling. During this stage the patie disability may be moderate or even severe but is not complete

These patients may be classified as falling into the sub-acute group T may either enter this group as the more acute symptoms abate or the partic lesions from which they suffer may never be associated with very severe pain disability

The treatment of this sub-acute group consists essentially of the applica of the two basic measures, rest and splinting of the lumbar spine. The relative v of these two measures is however not the same as in the management of pati with more acute symptoms. Splinting of the lumbar spine is the more impor measure and rest is usually only partial consisting of a restriction of activity

In an ambulant patient the lumbar spine may be splinted in two ways plaster jacket may be applied or the patient may be immobilised in a speci reinforced corset.

The plaster jacket is the most effective way of immobilising the lumbar s and its use is indicated in patients whose symptoms are relatively severe particularly in those who wish to continue their occupation and cannot there restrict their activities beyond a certain point.

To be effective, the plaster jacket must be close fitting comfortable rigid reasonably light. The application of such a jacket is not quite as simple a m as it might appear and very often unsatisfactory results from this form of treatn can be directly traced to an ineffective jacket.

The position of the patient during the application is important a satisfac jacket cannot be applied unless the patient is standing erect. Some author advocate the reinforcement of the erect position by head traction particul when a postural scoliosis is present, and consider that the use of such trac

is an important aid to immobilisation of the spine in the neutral position The author does not believe that such traction does in fact abolish a postural scoliosis, nor has he been able to detect any difference in the efficacy of jackets applied with and without head traction. If a postural scoliosis is present when a jacket is first used it tends to disappear as the symptoms abate when a new jacket can be applied.

The absolute minimum of padding should be used, as it is essential that the plaster should fit closely The best basis for a jacket is a double layer of stockinette, and the ordinary wide roll stockinette, being easily stretched will fit any patient. Two layers of this material are put on and the patient stands as erect as possible, the arms being abducted Using a broadsheet plaster or plaster slabs, the jacket is made with a minimum of delay It should extend from the pubis to the upper third of the sternum in front and from the middle of the sacrum to just below the scapulae posteriorly In the groin is should be moulded to allow flexion of the hips to 90 degrees so that the patient can sit in comfort. In the axillae the plaster should be low enough to allow unimpeded movement of the arms The plaster should be applied tightly and moulded close to the body When it has set the outer layer of stockinette can be turned over its edges to produce a smooth finish.

Such a plaster supports and immobilises the lumbar spine very effectively and is reasonably comfortable It is of course easier to apply if the patient is fairly thin, but it is rare to encounter a patient so very obese as to make the application of an effective jacket impossible.

Probably the most common errors are to apply the jacket too loosely or to make it too short in front. A loose plaster moves up and down and is uncomfortable, while unless it extends from the pubis to the upper third of the sternum a jacket will not control flexion of the spine.

A plaster jacket usually becomes a little loose in about four weeks and should then be re-applied It is surprising how often a patient will complain of a slight recurrence of symptoms as soon as the jacket starts to become slack.

Immobilisation of the spine in this way should be combined with some restriction of the patient's activity Although the jacket itself prevents movement of the lumbar spine certain specific actions should be avoided In addition, the patient should not engage in any pursuit which is strenuous or tiring

The movements which are potentially dangerous and harmful are those which impose a flexion strain on the spine and stooping and lifting should be avoided completely The patient should never attempt to reach anything by bending the back and when necessary an object at or near ground level should be reached by flexing the hips and knees Even when the spine is in the neutral position, the carrying of anything heavy imposes an extra strain on the damaged disc and should be avoided.

As regards general restriction, in the early stages of treatment the patient should lead as sedentary a life as possible The hours of daily activity should be reduced by rising late and retiring early and resting in the middle of the day

Standing or walking for more than 10 or 15 minutes at a time should be avoided as should prolonged sitting in one position

As the symptoms subside the patient may return gradually to a more normal mode of life The daily hours of activity are increased and the patient is allowed to stand or walk for gradually increasing periods at a time During this time the most reliable guide is the patient s symptoms It is usual to find that any untoward exertion or sudden increase in activity produces aching pain in the back or in the leg, and this is an indication that the patient is doing too much As the lesion heals so the patient s tolerance increases, but it is important, if improvement is to be maintained that as far as possible the limits of this tolerance should not be exceeded Flexion of or flexion strains on the spine continue to be dangerous and should be avoided completely at all times.

If the best results are to be achieved a plaster jacket must be worn continuously for some months Usually the patient s symptoms decrease sharply within the first two weeks of treatment and then continue to abate more slowly with irregular slight exacerbations and remissions Pain only disappears completely when the jacket has been worn for two or three months In general, the plaster should be retained for as long again as the time necessary to produce complete relief from pain four to six months being about the average period of immobilisation

When the jacket has been discarded the patient is fitted with a lumbar corset with incorporated Goldthwait steels This is worn at all times during the day and the patient is allowed to lead a normal life with the proviso that stooping and lifting are avoided. At this stage the management of the condition is as for a chronic lesion

An alternative to the plaster jacket as a means of immobilising the lumbar spine during the sub-acute phase is a lumbar corset with incorporated Goldthwait steels.

As compared to a plaster jacket, the corset has both advantages and dis advantages. The degree of immobilisation produced is not quite as complete nor are movements so effectively restricted, but on the other hand the corset is more comfortable and can be discarded in bed at night when it is least required It is also cleaner and less trying to wear during hot weather

As produced by instrument makers, lumbar corsets vary widely and many of the types in use are almost valueless To be effective the corset should extend from the pubis to the lower ribs in front and from the middle of the sacrum to just below the scapulae behind Posteriorly a steel support is incorporated, this being in the form of two vertical steel strips about four inches apart extending almost the full length of the corset. The ends of these vertical strips are connected by transverse strips and this oblong stiffener is made of stainless steel which must be slightly flexible and malleable It is bent to conform to the curve of the lumbar spine, sacrum and lower dorsal region so that it lies flat and does not stand away from the patient. In addition to the posterior steel supports the corset is slightly stiffened by boning on the lateral and antero-medial aspects. The reinforcement of these regions is best achieved by means of narrow strips of whalebone or plastic

is an important aid to immobilisation of the spine in the neutral position The author does not believe that such traction does in fact abolish a postural scoliosis, nor has he been able to detect any difference in the efficacy of jackets applied with and without head traction If a postural scoliosis is present when a jacket is first used it tends to disappear as the symptoms abate, when a new jacket can be applied

The absolute minimum of padding should be used, as it is essential that the plaster should fit closely The best basis for a jacket is a double layer of stockinette, and the ordinary wide roll stockinette, being easily stretched will fit any patient Two layers of this material are put on and the patient stands as erect as possible, the arms being abducted Using a broadsheet plaster or plaster slabs, the jacket is made with a minimum of delay It should extend from the pubis to the upper third of the sternum in front and from the middle of the sacrum to just below the scapulae posteriorly In the groin is should be moulded to allow flexion of the hips to 90 degrees so that the patient can sit in comfort. In the axillae the plaster should be low enough to allow unimpeded movement of the arms The plaster should be applied tightly and moulded close to the body When it has set the outer layer of stockinette can be turned over its edges to produce a smooth finish

Such a plaster supports and immobilises the lumbar spine very effectively and is reasonably comfortable It is, of course easier to apply if the patient is fairly thin but it is rare to encounter a patient so very obese as to make the application of an effective jacket impossible

Probably the most common errors are to apply the jacket too loosely or to make it too short in front. A loose plaster moves up and down and is uncomfort able, while unless it extends from the pubis to the upper third of the sternum a jacket will not control flexion of the spine.

A plaster jacket usually becomes a little loose in about four weeks and should then be re-applied. It is surprising how often a patient will complain of a slight recurrence of symptoms as soon as the jacket starts to become slack.

Immobilisation of the spine in this way should be combined with some restriction of the patient's activity Although the jacket itself prevents movement of the lumbar spine, certain specific actions should be avoided In addition, the patient should not engage in any pursuit which is strenuous or tiring

The movements which are potentially dangerous and harmful are those which impose a flexion strain on the spine, and stooping and lifting should be avoided completely The patient should never attempt to reach anything by bending the back and when necessary an object at or near ground level should be reached by flexing the hips and knees Even when the spine is in the neutral position, the carrying of anything heavy imposes an extra strain on the damaged disc and should be avoided

As regards general restriction in the early stages of treatment the patient should lead as sedentary a life as possible The hours of daily activity should be reduced by rising late and retiring early and resting in the middle of the day

Standing or walking for more than 10 or 15 minutes at a time should be avoided as should prolonged sitting in one position

As the symptoms subside the patient may return gradually to a more normal mode of life The daily hours of activity are increased and the patient is allowed to stand or walk for gradually increasing periods at a time During this time the most reliable guide is the patient s symptoms It is usual to find that any untoward exertion or sudden increase in activity produces aching pain in the back or in the leg and this is an indication that the patient is doing too much As the lesion heals so the patient s tolerance increases but it is important if improvement is to be maintained that as far as possible the limits of this tolerance should not be exceeded Flexion of or flexion strains on the spine continue to be dangerous and should be avoided completely at all times.

If the best results are to be achieved a plaster jacket must be worn continuously for some months Usually the patient s symptoms decrease sharply within the first two weeks of treatment and then continue to abate more slowly with irregular slight exacerbations and remissions Pain only disappears completely when the jacket has been worn for two or three months In general the plaster should be retained for as long again as the time necessary to produce complete relief from pain four to six months being about the average period of immobilisation

When the jacket has been discarded the patient is fitted with a lumbar corset with incorporated Goldthwait steels This is worn at all times during the day and the patient is allowed to lead a normal life with the proviso that stooping and lifting are avoided At this stage the management of the condition is as for a chronic lesion

An alternative to the plaster jacket as a means of immobilising the lumbar spine during the sub-acute phase is a lumbar corset with incorporated Goldthwait steels.

As compared to a plaster jacket the corset has both advantages and disadvantages The degree of immobilisation produced is not quite as complete nor are movements so effectively restricted but on the other hand the corset is more comfortable and can be discarded in bed at night when it is least required It is also cleaner and less trying to wear during hot weather

As produced by instrument makers, lumbar corsets vary widely and many of the types in use are almost valueless To be effective the corset should extend from the pubis to the lower ribs in front and from the middle of the sacrum to just below the scapulae behind Posteriorly a steel support is incorporated this being in the form of two vertical steel strips about four inches apart extending almost the full length of the corset. The ends of these vertical strips are connected by transverse strips and this oblong stiffener is made of stainless steel which must be slightly flexible and malleable It is bent to conform to the curve of the lumbar spine, sacrum and lower dorsal region so that it lies flat and does not stand away from the patient. In addition to the posterior steel supports the corset is slightly stiffened by boning on the lateral and antero-medial aspects The reinforcement of these regions is best achieved by means of narrow strips of whalebone or plastic

material which combines rigidity with flexibility The best method of fastening the corset is by employing straps and buckles, there being three or four anterior straps and two or more long lateral straps which extend round about three-quarters of the circumference of the corset. Such straps and buckles are easier to adjust than lacing and have the great advantage that each can be tightened individually

The corset is worn at all times during the day but is usually discarded in bed at night. A few patients with fairly severe symptoms prefer to retain the support even in bed because they feel more comfortable when the lumbar spine is held rigid

During treatment the patient's activities are restricted in precisely the same way as in the case of a patient wearing a plaster jacket The corset is retained for two or three months after the symptoms have disappeared the whole period of treatment usually being about six months.

As has been pointed out, the plaster jacket and the lumbar corset have their relative advantages and disadvantages. Broadly speaking, the jacket is indicated in patients with severe symptoms or in those who are active by habit while the corset is used when symptoms are less severe or when the patient is prepared to lead a very sedentary life. Moreover all patients who have been immobilised in plaster use a corset for two or three months when the jacket has been discarded, as immobilisation of the lumbar spine should never be ceased abruptly When it is considered safe, the corset is discarded gradually being left off for an hour or two each day at first. If no untoward symptoms occur it is then dispensed with for longer and longer periods and ultimately abandoned completely

The successful treatment of patients in the sub-acute group produces a gradual diminution and final disappearance of symptoms over a period of several months. Progress is not necessarily or even usually uniform and in most patients slightly irregular remissions and exacerbations occur In this group conservative treatment may be considered to have failed if during treatment any severe exacerbation occurs or if symptoms either do not abate at all or persist unchanged after some initial improvement Should conservative treatment fail in this way other measures must be considered.

3 Treatment of Patients with Chronic Symptoms:

Nowhere is the lack of any sound pathological basis for classification of patients into groups depending on whether their symptoms are acute, sub acute or chronic, more apparent than in the case of the third of these groups. Patients with chronic symptoms are those that complain of nagging pain in the low back or leg, the pain tending to be fairly constant although of varying intensity Complete freedom from symptoms is rare and exacerbations are never very severe.

Such symptoms may be produced by a lumbar disc lesion at widely differing stages. In the earlier phase of nuclear degeneration without annular rupture chronic low back pain is usual After annular rupture and nuclear retropulsion and when healing has taken place, root adherence may produce chronic sciatica. In the

final stages of a disc lesion intervertebral arthritis always produces chronic symptoms

From the point of view of conservative treatment, however the basic principles remain the same and the management of patients with chronic pain and slight disability is essentially similar irrespective of the stage of the lesion producing such symptoms.

The lumbar spine is immobilised in a lumbar corset with incorporated Goldthwait steels and activity is restricted The corset is worn at all times during the day and the patient is warned not to engage in any strenuous pursuits Flexion strains on the lumbar spine are especially to be avoided any stooping lifting or carrying of heavy weights being expressly forbidden

In the chronic group the prognosis and the response to treatment depends very largely on the underlying pathological conditions

Patients with early lesions and nuclear degeneration only usually respond well, becoming symptom free in one or two months It is very important, however that treatment be continued for several months, as if it is abandoned too soon symptoms inevitably recur

The patient with chronic sciatica due to an adherent root always presents a difficult problem The response to treatment tends to be doubtful and at best symptoms diminish very slowly

When chronic symptoms are due to intervertebral arthritis the response to conservative treatment is usually reasonably satisfactory With effective immobilisation and avoidance of flexion strains the pain disappears and the patient becomes more comfortable. Unfortunately however these patients very often relapse after treatment has been abandoned, particularly if they do anything which is too strenuous. When such relapses occur one of two courses may be followed Either the patient must decide to wear a corset and to avoid flexion strains indefinitely or operative fusion of the spine must be carried out. In fact, many of these patients do continue treatment intermittently for the rest of their lives When symptoms are present the corset is worn and activities are curtailed while during periods of remissions the support may be discarded and a more active life lead.

MANAGEMENT OF A LUMBAR DISC LESION DURING PREGNANCY

During the latter half of pregnancy the generalised softening of fibrous tissue in the lumbar and pelvic regions and the abnormal strains on the lumbar spine increase the vulnerability of the lower lumbar discs If a degenerative disc lesion exists it is extremely likely to become active and associated with acute symptoms, and quite often such a lesion first develops during this time.

During pregnancy the management of the patient with severe symptoms is always difficult and the response to treatment is usually poor

It is impossible to immobilise the lumbar spine as the use of a plaster jacket or lumbar corset is impractical. A simple decrease in activity is always indicated but the presence of a gravid uterus throws an increased strain on the lumbar spine

so that even the most sedentary life is associated with severe demands on the low back.

Long daily periods of rest in bed are indicated and if the patient's symptoms remain severe complete and continuous rest is the only possible treatment. It is not unusual for patients with an active disc lesion to be forced to spend the last three or four months of pregnancy confined to bed.

When severe pain is only partially controlled by rest it may be necessary to induce labour as soon as this can be done with safety Such an induction may save the patient three or four weeks continuous pain and there is always the possibility that delivery will be materially easier if the baby is slightly premature.

The help of the obstetrician should be enlisted so that during the actual delivery as little strain as possible is transmitted to the lumbar spine After delivery the symptoms tend to decrease in most cases. If this is so a lumbar corset should be worn when the patient is allowed to get up and restricted activity with careful avoidance of flexion strains is indicated for some months

In some patients symptoms persist unchanged even after delivery and this is particularly liable to occur when severe sciatica is present. If symptoms continue to be severe and incapacitating without improvement for six weeks or two months a massive nuclear retropulsion must be suspected and the question of operation must be considered.

CHAPTER XIII

THE CONSERVATIVE TREATMENT OF LUMBAR DISC LESIONS

(*Continued*)

OTHER FORMS OF CONSERVATIVE TREATMENT

SUFFERERS from the lumbago sciatica syndrome have one consolation although this is of a somewhat dubious nature This condition appears to have a popular appeal second to none and inevitably an overwhelming number of cures will be forced on their attention Although the cures which do not originate from medical sources need not be considered in detail, they are not without their interest. A number of the author's patients have kept lists of the certain remedies which were urged on them by friends and acquaintances and even by complete strangers Ranging from herbal preparations dietetic measures and local applications to various remedial exercises and stretchings these are unbelievably numerous and must be some indication of the widespread incapacity and suffering produced by disc lesions.

The measures originating from purely medical sources are hardly less diverse and often of little more value. Only those in fairly general use need be considered and unfortunately many of these merit consideration because of their popularity rather than on account of any intrinsic virtue

A BLISTERING OR SCARIFICATION OF THE SKIN

It might be supposed that with the advances in the knowledge of the pathology of lumbar disc lesions the practice of blistering or scarifying the skin in the lumbar region or leg for patients with low back pain or sciatica would have disappeared Such is by no means the case, however The more picturesque dry-cupping and scarification knives may not be used but blistering is still common and skin puncture by no means unknown. A Kromeyer burn is only a superficial burn despite being produced by irradiation. Such measures have no value

B PHYSIOTHERAPY

Physiotherapy in various forms is very widely used in the treatment of disc lesions, even after the diagnosis has been established Some of the measures employed may temporarily allevlate the patient's symptoms but none have any permanent value.

(1) Heat

Heat in various forms is probably the most commonly prescribed treatment for low back pain Radiant heat infra red radiation short wave diathermy and even

ultra violet radiation each have their advocates Some patients appear to derive temporary relief from any form of heat applied to the lumbar region, probably because local muscle spasm is decreased Such relief is, however transient and there is no evidence to suggest that local heat has any effect on a disc lesion or any lasting effect on the patient's symptoms In a few instances symptoms are definitely made worse by heat in any form

(2) Massage

Gentle massage of the lumbar region may temporarily diminish muscle spasm and make a patient more comfortable Vigorous massage and particularly any attempt to find nodules in the lumbar muscles, does no good and may even do harm.

(3) Exercises and Electrical Stimulation of Lumbar Muscles

Gentle extension exercises of the spine and sometimes faradic stimulation of the erector spinae muscles may be of value, particularly as a post-operative measure Such treatment must always be carried out with great discrimination and it should be remembered that the intention is to restore muscle tone and build up muscle bulk rather than to improve the range of spinal movement.

(4) Spinal Exercises:

Vigorous active exercises of the spine have no place in the treatment of a disc lesion at any stage Such exercises simply increase the strains and stresses to which the damaged disc is subjected and thus delay or prevent healing.

C EXTRATHECAL INJECTION OF SALINE

The injection of saline solution containing a small percentage of local anaesthetic into the extrathecal space has been used in the treatment of disc lesions, particularly when sciatica is a prominent symptom A needle is introduced through the sacral foramen and some 20 to 40 cubic centimetres of solution with perhaps a half per cent. of a suitable local anaesthetic is run into the extrathecal space under very low pressure. This produces a caudal anaesthesia the extent of which depends on how high the solution spreads upwards around the theca and extrathecal roots. When the anaesthetic effect does extend to the level of the disc lesion the symptoms must either be alleviated or disappear completely until the anaesthetic wears off Beyond this it is very doubtful if such an injection has any effect at all. It is sometimes claimed that it acts by breaking down adhesions between the affected disc and the spinal theca and also any adhesions which exist around an extrathecal root. Anyone who has had opportunities of exploring the adhesions which may form between an abnormal disc and the adjacent structures must feel that the chances of such adhesions being affected by fluid infiltrated into the extrathecal space under very low pressure are very remote indeed

D INJECTION OF LOCAL ANAESTHETIC

Very commonly an attempt is made to relieve the patient's symptoms by injecting a weak solution of local anaesthetic into the most painful or most tender areas in the lumbar region In the case of the much less common local lesions which produce low back pain such injections may have some therapeutic or diagnostic value. Fortunately however the lumbar intervertebral discs are sufficiently inaccessible to make the injection of local anaesthetic directly into the discs too hazardous a procedure to be popular For this reason local infiltration of the affected disc is rarely attempted and it is extremely unlikely that it would do any permanent good if it were achieved Infiltration elsewhere has no effect on a disc lesion

E. INJECTIONS INTO THE DISCS THEMSELVES

When some six years ago the author first stated that injection into the discs themselves was too hazardous to become popular he underestimated the resolution of some of his colleagues.

Nucleography was suggested by Erlacher[1] in 1952 and since then disc puncture has been advocated from time to time both for diagnostic and therapeutic purposes

Having been used in the treatment of almost every other orthopaedic lesion in the body it seemed inevitable that hydrocortizone should sooner or later be introduced into an intervertebral disc Feffer[2] has suggested the direct injection of hydrocortizone into the disc during the first stage of a disc lesion, that is before annular rupture. He believes that the local anti inflammatory action of this drug might reverse or block the changes in the disc and reports remission of symptoms in 67 per cent. of 55 patients so treated.

The dangers of blind puncture of an intervertebral disc have already been discussed in connection with nucleography The author believes that the theca, the extrathecal roots and the disc itself may be damaged by this procedure and considers that in certain circumstances root damage may be unavoidable. In the unlikely event of the author ever wishing to inject something directly into an inter vertebral disc as a therapeutic measure hydrocortizone is not the substance he would choose.

F MANIPULATION OF THE LUMBAR SPINE

Patients suffering from symptoms produced by a lumbar disc lesion are very often subjected to various forms of manipulative treatment Indeed manipulation of the spine either with or without an anaesthetic is so commonly carried out by both qualified and unqualified practitioners that it must be assumed that some patients benefit from this procedure From time to time patients who appear to be reliable witnesses state that their symptoms have been relieved more or less dramatically by manipulation although they usually add that such relief was transient It must be pointed out at this juncture that the reverse is even more

[1] Erlacher P R. (1952) Nucleography *J Bone Jt Surg* 34-B, 2, 204-210.
[2] Feffer H L. (1956) Treatment of Low Back and Sciatic Pain by the Injection of Hydrocortizone into Degenerated Intervertebral Discs. *J Bone Jt Surg.*, 38-A, 585-592.

commonly true and that many patients can either trace the onset of severe symptoms to a spinal manipulation or state very definitely that they have had much more pain following this form of treatment

Many types of manipulative treatment and many special manoeuvres have been described from time to time It is almost universally true however that while the procedure advocated is described in great detail the authors never state with what object the particular passive movements are carried out or exactly how they may be expected to affect the lumbar spine In fact no attempt is made to describe or to postulate the effects of manipulation in relation to the pathological condition which is responsible for the patient s symptoms One is driven to the conclusion that either manipulative treatment as it is practised is largely empirical or that the advocates of manipulation believe in the existence of some pathological condition quite different from the accepted conception of a lumbar disc lesion in its various stages

In fact the possible effects of passive movements on disc lesions are quite clear and it is a simple matter to decide which particular passive movements are likely to produce these effects The effects themselves may be temporarily beneficial or harmful and largely depend on the particular stage which the lesion has reached when the patient is subjected to manipulation

(*a*) In the earlier stage of nuclear degeneration the only possible dramatic effect of a manipulation would be the rupture of the already weakened posterior annulus and such rupture might be associated with nuclear retropulsion. The movements most likely to produce this effect are those which stretch the posterior part of the annulus and posterior longitudinal ligament, that is, flexion of the lumbar spine. At this stage, therefore, manipulation could do no possible good and may do great harm by damaging the already weakened disc and changing the patient's symptoms from chronic backache to acute low back pain possibly associated with sciatica

(*b*) During the stage of nuclear retropulsion there is one circumstance in which the patient s symptoms may be definitely if temporarily relieved by manipulation. If a nuclear sequestrum has become impacted between the posterior rims of the vertebral bodies producing a locked back any movement which separates the posterior parts of these bodies may free the sequestrum and allow it to slip back into the central concavity of the joint thus unlocking the back Flexion of the spine tends to open up the vertebral bodies posteriorly and free the sequestrum and it is possible that extension of the spine may achieve the same effect by squeezing the sequestrum back into place (Fig. 46) There can be no doubt that an unlocking of the spine in this manner may sometimes produce a dramatic improvement in the patient s symptoms and it is probably on such incidents that the reputation of manipulation as a form of treatment is based It must be pointed out, however that this manoeuvre is in no way under the control of the manipulator and that the prospects of success depend entirely on factors which cannot be assessed If the sequestrum is impacted so that its main bulk remains inside the annulus it will tend to slip forwards If on the other hand, the major part of the

sequestrum has already passed through the annulus and if as so often is the case, it is only retained in this position because it has not separated completely manipulation cannot cause it to move forwards and is much more likely to produce a complete extrusion with a sharp exacerbation of the patient's symptoms due to increased pressure on the cauda equina or extrathecal roots (Fig 47)

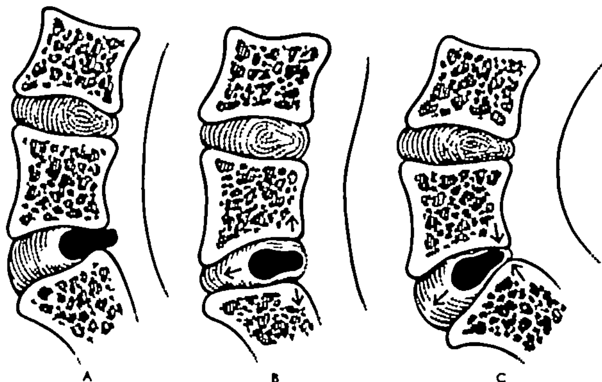


FIG. 46

Effects of manipulation on impacted sequestrum

If a nuclear sequestrum is impacted so that its greatest bulk lies between the vertebral bodies (A) it may be affected either by flexion or extension of the spine Flexion opens up the bodies posteriorly and the released sequestrum may slip anteriorly into the central concavity (B) Extension, by closing down the bodies posteriorly may squeeze the sequestrum forward (C)

Further during the stage of nuclear retropulsion a manipulation of the spine particularly if the manipulation includes vigorous passive flexion may produce a wide tearing of the annulus with massive nuclear retropulsion. Such a massive nuclear displacement, which is a very unusual phenomenon except in special circumstances may produce sudden severe cauda equina pressure and permanent paraplegia. Examples of these tragic results of ill judged manipulative treatment are to be found both in this country and in America

It is clear therefore that if an impacted sequestrum producing a locked back is not present manipulation during the stage of nuclear retropulsion can do no good and may very well do harm Even if such a sequestrum is present manipulation is just as likely to cause its complete extrusion as to force it forward between the vertebral bodies. More if the most satisfactory possible result is achieved by manipulation that is if an impacted sequestrum is restored to the central concavity

between the vertebral bodies where it causes the least trouble this is in most cases a purely temporary benefit Unless measures are taken to promote healing further displacement is almost inevitable

(c) A disc lesion in its third stage may be affected in various ways by manipulation. There are, however only two circumstances in which the effect can be beneficial.

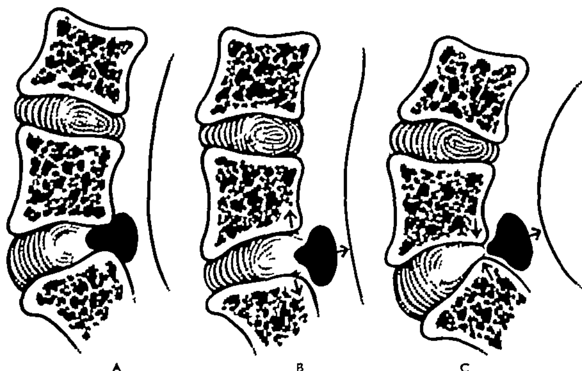


FIG. 47

Effects of manipulation on impacted sequestrum

A nuclear sequestrum impacted between the vertebral bodies so that its greatest bulk projects into the spinal canal (A) may also be affected by flexion or extension of the spine Flexion opens up the bodies posteriorly and the released sequestrum may slip backwards in its entirety (B). Extension by closing down the bodies may force the sequestrum backwards (C).

If a root in its extrathecal course has become adherent to a scarred disc it is just possible that any manipulation which moves or produces tension in the fixed root may stretch or break down the adhesions with a subsequent diminution of the patient s symptoms. There are of course, many ways of stretching the extrathecal root but the simplest and most effective is forcibly to raise the straight leg. This type of manipulation was formerly much employed and patients with sciatica were subjected to repeated stretchings with the idea of breaking down adhesions which were said to involve the sciatic nerve The results were so unsatisfactory however that this form of treatment has now largely been abandoned It is not surprising that results of attempts to free an adherent root by closed manipulation should be so uncertain. Adhesions round a scarred disc may be so massive and firm that even when the root is exposed at operation it can only be freed by sharp dissection Indeed in the later stages it may be involved in calcification which must be chiselled

away before it can be mobilised Any attempt to break down such adhesions by pulling on the root itself is obviously futile In fact too forcible a manipulation very often does harm and may either produce an exacerbation of symptoms or even complete root section

The second circumstance in which a manipulation might help occurs in the late stages of a healing lesion An intervertebral joint in which degenerative arthritis is present but which has not reached the stage of fibrous ankylosis may be temporarily benefited by a gentle manipulation The increased range of movement achieved is associated with a decrease in the patient s symptoms It must be pointed out however that the effect of stretching such a joint is unpredictable If the joint is irritable or if the manipulation is too vigorous a flare of the arthritis may cause a sharp exacerbation of the patient s symptoms.

It seems clear therefore that there are only three possible pathological circumstances in which a manipulation may alleviate the symptoms produced by a lumbar disc lesion Unless one of these exists a manipulation can do nothing but harm More, even in favourable circumstances it is by no means certain that a manipulation will have the desired effect and on the contrary it may produce harmful or even catastrophic results. The results produced are largely a matter of chance and are not in any way under the direct control of the manipulator and at best any improvement achieved is essentially temporary the patient s symptoms diminish for a time but the disc lesion remains essentially unchanged

For these reasons the author believes that manipulative treatment in any form has a very limited and probably evanescent place in the management of lumbar disc lesions.

G TREATMENT BY TRACTION

During the past few years the treatment of disc lesions whether lumbar or cervical, by manipulation has become less popular and it seems probable that the dangers and limitations of this method are now more widely appreciated None the less the search for a form of treatment with a mechanical basis and some dramatic appeal continues and the place of manipulation has been largely taken by traction.

In essence this form of treatment consists of applying indirect and opposing pulls to the spine in its longitudinal axis thus tending to separate the vertebrae above and below the affected disc.

In so far as it has any logical basis at all presumably the aim of such traction is to reduce the positive pressure within the annulus by separating the vertebral bodies and so to allow displaced nuclear sequestra to slip back into place or even to be sucked back into place

In fact the effects on the disc of forcible separation of the vertebrae above and below are far from simple

If the disc is normal and the annulus intact separation of the vertebral bodies simply allows the nucleus to change shape and the fibres of the elastic annulus become straight instead of being slightly bulged outward The degree of separation

possible is determined by the annulus When its fibres become taut movement is checked and further separation can only be achieved by the application of a distracting force sufficient to tear or detach these fibres A force sufficient to do this to a healthy disc would have to be very powerful and it is doubtful if it could be produced by any but the most efficient traction apparatus and certain that it would not be tolerated by an unanaesthetised patient As far as pressure within a normal nucleus is concerned this is not affected by vertebral separation unless and until annular rupture takes place, up to this point the nucleus simply alters in shape

In the presence of a lumbar disc lesion however the effects of traction are very different and various very real hazards arise

During the first stage of a disc lesion, that is when the nucleus and posterior annulus are degenerating and softening but before annular rupture, forcible separation of the vertebral bodies may tear the weakened annulus and precipitate nuclear retropulsion. At this stage traction can do no possible good and may easily do harm

During the stage of nuclear retropulsion traction may affect the disc in several ways If sufficient force is applied the already ruptured annulus may be torn further On the other hand during the actual traction compression forces on the disc decrease or disappear and the tendency to further nuclear retropulsion is diminished so long as the traction is maintained While the compressing forces on the disc are counteracted and decreased by traction there is, however no question of the pressure within the annulus becoming negative that is there is no possibility of a displaced sequestrum being sucked back into place between the vertebral bodies. The only circumstance in which a sequestrum may be affected by traction is when it is impacted between the posterior rims of the vertebral bodies. Such a sequestrum may be freed when the vertebrae are separated and may then slip forwards or backwards, depending on whether or not the major part of its bulk had passed through the annular defect before it became impacted If it slips forward into the concavity between the vertebral bodies the patient s acute symptoms are reduced if it slips backward into the spinal canal it may cause pressure symptoms. The direction in which such a sequestrum may move cannot of course be controlled in any way by traction

During the third stage, that is during the stage of repair when the intervertebral joint is being converted into a firm fibrous ankylosis, traction can do nothing but harm Separation of the vertebral bodies tends to tear the newly formed fibrous tissue and prevents the development of a stable painless ankylosis. Even organised fibrous tissue can be broken down by repeated heavy traction and an unstable irritable joint may be produced

The effects of traction on lumbar disc lesions in their various stages have been considered at some length because, in the opinion of the author this form of treatment can do little good and may easily do considerable harm.

The means by which traction is achieved vary widely Usually it is applied intermittently but its duration and the intervals between tractions seem to be a

matter of individual choice The force used depends entirely on the efficiency of the apparatus at the disposal of the operator

In its crudest form traction is manual The patient lies flat and is grasped in the region of the pelvis and shoulders by two physiotherapists who pull against each other This causes a patient with an acute lesion considerable discomfort and only when the physiotherapists are very large and the patient very small is it likely that any effective traction is achieved Various portable mechanisms for traction exist. These consist of a system of slings and belts which are fastened to the patient and pulled on by weights slung over the end of the bed No real traction is produced by such methods

While the makeshift methods already described are unlikely to produce enough pull to do any harm it is quite another matter when the real traction table is considered In the early years of this century traction was a very popular method of treatment particularly among osteopaths, and it was usually achieved by the use of such traction tables Subsequently this method largely fell into disrepute but in the past few years many of these tables have been resurrected from dusty retirement in the attic and put into service again Modern and even more efficient models have been constructed and the traction table is now almost a stock fitting in any physiotherapy department The patient lies on a flat, relatively friction free surface and is anchored by the pelvis and legs and by the thorax and shoulders Distracting force is applied to the lower spine by a geared mechanism in the table and because of the gearing very considerable force may be generated simply by turning a handle There is no doubt at all that the injudicious use of such a machine can tear a weakened or ruptured annulus widely

To sum up therefore, the only circumstance in which traction can relieve a patient with a disc lesion is when separation of the vertebral bodies allows an impacted sequestrum to slip forwards into the central concavity between these bodies. This manoeuvre cannot be controlled in any way and even when it has been achieved subsequent redisplacement is probable unless the patient is then treated by rest and immobilisation of the lumbar spine It is also true that during traction compression forces on the disc are reduced and any tendency to nuclear retropulsion temporarily diminished All the other possible effects of traction are harmful in greater or lesser degree depending on the force used

H DEEP X RAY THERAPY

A few clinicians have advocated and employed irradiation by deep X ray in the treatment of lumbar disc lesions There seems to be no evidence to suggest that such irradiation has any effect on a degenerate disc nor have the reported results of such therapy been satisfactory

RESULTS OF CONSERVATIVE TREATMENT OF DISC LESIONS

It is always very difficult to assess the results of treatment in a condition which is never fatal which produces a varying degree of disability and which tends to

be markedly episodic in its effects With lumbar disc lesions certain additional difficulties also arise.

Most of the published statistical reviews have been carried out in hospitals but not all patients with lumbar disc lesions attend any one hospital department. Indeed many with mild symptoms are never considered to be suffering from disc lesions at all but are labelled fibrositis, low back strain, sciatica or some similarly vague and incorrect diagnosis. These patients are treated in Casualty Departments and some appear to recover partially or completely more or less spontaneously while others become discouraged and cease attending that particular hospital.

More, not all patients with severe or persistent symptoms are ultimately referred to any one department. Many and in particular those in whom low back symptoms are predominant, are sent to the Orthopaedic Department. Others go to the Medical Neurological or the Neuro-Surgical Department with a diagnosis of sciatica and still others are referred to the Physiotherapy Department, the Rheumatological Department, if such a department exists in that particular hospital, or even to the gynaecologists. No one department therefore can produce authoritative figures about the results of treatment in all patients suffering from disc lesions

It is customary and popular at the present time to state that a very high proportion of patients recover with conservative treatment. Many orthopaedic surgeons do not hesitate to claim that operation is only necessary in between 5 per cent. and 2 per cent. of all patients and that the remainder will recover if the conservative measures are adequate

Such statements are not in accord with the published results In nine published series dealing with 596 patients the results of conservative treatment were unsatisfactory in 59 per cent. of patients. In a series of patients with a positive myelogram Colunna and Friedenberg[1] reported that after conservative treatment 71 per cent. of patients had residual pain 77 per cent. of those were labourers and were forced to change their occupation, and 32 per cent. of patients were dissatisfied

In the author's opinion the results of conservative treatment cannot be assessed in any simple and conclusive manner Patients fall into one of three broad groups.

First, a small percentage become and remain completely and permanently symptom free and can engage in any activity they please. The author does not consider that this group exceeds 20 per cent. of all patients and this desirable result is more likely to be achieved if the patient's symptoms are mild than if they are severe.

The second group fail to respond to conservative treatment and their symptoms persist to such a degree that operative treatment ultimately becomes necessary In the author's opinion this happens in between 10 per cent and 20 per cent of all patients and is much more likely to occur when symptoms are severe than when they are moderate or mild

[1] Colunna, Paul C., & Friedenberg, Z. B. (1949) The disc syndrome results of the conservative care of patients with positive myelograms. *J Bone Jt Surg* 31 A 614

In the third and by far the largest group conservative treatment reduces the severity of symptoms to an extent which makes them compatible with a normal life Some restriction of activity is necessary and the patient may have to wear a supporting corset for at least part of the time Occasional exacerbations of the residual symptoms occur usually as a result of some injudicious increase in activity These results are in the main fairly satisfactory and the patients are content but quite obviously the standard desirable varies with the age occupation and habits of the patients. A reduced tolerance for activity which is quite acceptable to an elderly person of sedentary habits may be quite unsatisfactory in the case of a young active man with a strenuous occupation Pain which is unsupportable in a nervous or highly strung patient may be tolerable to a person of a more phlegmatic temperament.

CHAPTER XIV

THE OPERATIVE TREATMENT OF LUMBAR DISC LESIONS

OPERATION is a most important measure in the treatment of lumbar disc lesions, indeed without surgical intervention a material proportion of patients with severe symptoms cannot be relieved At the same time it must be recognised clearly that operation is not of itself a complete cure but is rather an incident in the management of certain types of disc lesions. Once its exact place is appreciated the contribution of operative treatment is unassailable

THE INDICATIONS FOR OPERATION

It is vital that the indications for operation should be as clear as possible. The Scylla of unnecessary surgery with its attendant risks is no more desirable than the Charybdis of avoidable disability and irreversible change.

The difficulty is that few hard and fast rules can be laid down In the main *the indications are of a general nature and must be interpreted with regard for* the circumstances of each individual case Quite naturally the interpretation will vary to some extent with the personal views of the surgeon concerned but there is now sufficient evidence of the place and value of operative treatment to make extreme conservatism and undue eagerness to operate equally unjustifiable

There are three indications for operation in the treatment of lumbar disc lesions.

1 Failure of Conservative Treatment:

This is by far the most usual indication and also the most difficult to assess accurately The residual symptoms must be considered in relation to the patient's temperament, physique, occupation and habits. The problem may be simple particularly if symptoms are severe, or it may be extremely difficult. A period of observation is often valuable but undue delay may jeopardise the success of operative treatment.

In general the failure of conservative treatment may be considered in relation to patients with acute, sub-acute and chronic symptoms.

(a) Patients with acute symptoms, that is with severe and incapacitating pain require operation in two circumstances

If these symptoms persist unremittingly in spite of complete rest for some weeks operative treatment is indicated When a patient is not relieved by simple bed rest traction a plaster shell or a spica may be tried but if these measures prove of no value surgical intervention should not be delayed In these circumstances between three and six weeks is a fair trial period and the continued

persistence of severe symptoms beyond this time indicates the presence of a nuclear sequestrum which must be removed to produce relief

If acute and crippling symptoms having responded to treatment recur at short intervals so that the patient is constantly apprehensive lest sudden incapacitating pain may follow some trivial exertion operation is also indicated Remissions of this nature indicate recurrent extrusion or partial extrusion of a nuclear fragment or fragments which must be removed if favourable conditions for healing are to be established

(*b*) The indications for operation are more difficult to assess if the patient s symptoms are sub acute Broadly speaking surgical treatment is necessary if conservative measures cannot render the patient sufficiently comfortable to be able to live a normal life It might be that residual symptoms are constant that remissions are frequent or that the patient s tolerance for activity is unduly restricted Any of these circumstances may constitute an indication for operation but each patient presents an individual problem which must be assessed on its merits.

(*c*) The patient with chronic symptoms presents exactly the same problem Operation is indicated if the residual symptoms are too severe to be easily tolerable, if remissions are frequent or if tolerance for activity is unduly low

2. Massive Nuclear Retropulsion with Cauda Equina Pressure

There is one circumstance in which the indication for operation is clear Massive nuclear retropulsion with cauda equina pressure is a rare occurrence which usually only takes place as a result of fairly severe injury or during or soon after pregnancy but when it does occur immediate surgical intervention is indicated Unless the pressure on the cauda equina is relieved within a few hours subsequent recovery is always imperfect. There must be no hesitation and no period of observation if the surgeon is in doubt the level of the retropulsion may be determined by myelography but decompression must be carried out at once. Cauda equina pressure produced in this way constitutes a surgical emergency at least as grave as an intestinal perforation and the prognosis depends directly on how soon the pressure is relieved

3 Effects of Severe and Persistent Interference with Root Function:

An extruded sequestrum may either stretch or compress a root in its extrathecal course. Three factors determine whether or not actual compression takes place, the size of the extruded sequestrum the position of the sequestrum relative to the root and the shape and size of the bony canal. Root compression is associated with loss of root function and is indicated by sensory change and muscle weakness and wasting rather than by pain. Muscle weakness and wasting in particular indicate severe interference with root function If compression is allowed to persist too long irreversible changes take place in the root itself and impairment of function is permanent

If there is obvious clinical evidence of compression and in particular if muscle weakness is a prominent feature operation is indicated if symptoms do not improve

rapidly with conservative treatment. How long this treatment should be tried in these circumstances is a matter of some controversy The author considers that it depends largely on the degree of interference with root function. If the pressure is sufficiently severe to interrupt conduction completely as indicated by marked weakness or even complete paralysis of a muscle group decompression should be carried out if these symptoms persist unchanged for more than a few days. When symptoms are less severe conservative treatment may be persisted with for two or three weeks. Broadly speaking, in such circumstances operation is usually deferred far too long. The author has never regretted early surgical intervention when evidence of root compression was present but has often regretted not operating sooner in cases in which upwards of a year has been necessary before root function returned to normal after decompression

CONTRAINDICATIONS TO OPERATION

There are, of course, many patients with typical disc lesions and severe symptoms for whom operation is not indicated. This is not because their particular lesions are not amenable to surgical treatment—there are no disc lesions which cannot be dealt with surgically—operation is only contraindicated in that it is not necessary

The practising surgeon who specialises in the surgery of the low back sees many patients who have been referred to him for operation In the author's experience surgery is unnecessary in a surprisingly high proportion of such cases and from the practical point of view it is contraindicated for one of three reasons.

1 Inadequate Conservative Treatment:

Failure of conservative treatment only becomes an indication for operation when such treatment has been adequate Cauda equina pressure evidence of severe root compression and persistent very severe pain are the only circumstances which justify immediate or early surgical interference Otherwise operation is never a matter of urgency and conservative measures should be given a thorough trial before being abandoned

When deciding whether or not conservative treatment has been adequate all measures other than rest and immobilisation of the low back can be ignored. Acceptable standards of both of these have been suggested already and it is essential that treatment should have been sufficiently prolonged.

2. Doubt in the Diagnosis

A tentative exploration of the lower lumbar discs in patients with obscure low back pain is usually an extremely unsatisfactory procedure and before operating the surgeon should be reasonably certain that the diagnosis is accurate.

It is true, of course, that some lesions not associated with root involvement require operation. In these circumstances it is always more difficult to establish the diagnosis and it may be quite impossible to be certain of the level of the lesion in patients complaining of low back pain alone. It may then be necessary to explore

the lower two or three lumbar discs to locate the lesion but its actual presence should have been established clinically beyond any reasonable doubt before operation

There are perhaps two outstanding types of cases in which there is a particularly strong temptation to explore the lumbar disc unjustifiably

The first is the patient with low back pain and symptoms indicating involvement of a root or roots at more than one level While it is possible that this syndrome may be due to a disc lesion or lesions the possibility of the existence of a cauda equina tumour must be remembered Exploration of the lower discs does not necessarily or even often reveal the presence of such a tumour and should only be undertaken in such cases when the cerebrospinal fluid is normal and a myelogram is negative

The second is the patient with chronic low back pain for which no obvious cause can be found In such cases sooner or later exploration of the discs is suggested as a council of despair The results of such explorations are rarely satisfactory

3. The 'Neurotic' Patient

Neurosis cannot be removed surgically and this is particularly true if the neurosis is localised to the low back It is therefore obviously undesirable to operate on patients when there is a large functional element in their complaints and indeed the results of such operations can be depressing in the extreme At the same time low back pain is a demoralising condition and often has a most devastating effect on the temperament and disposition of the patient When such effects are obvious the patient is often unjustly suspected of exaggerating symptoms or even of malingering. In these circumstances when a genuine lesion is present the results of operation can be extremely gratifying to both patient and surgeon

Some degree of functional overlay is therefore to be expected in all patients with an active disc lesion and the surgeon must decide whether or not this is a major factor in the patient's complaints. Provided sufficient regard is paid to the clinical signs as opposed to the symptoms it should be possible to avoid operating on patients whose symptoms are in the main functional.

AIMS OF OPERATION

The primary aim of operation is the complete removal of the nucleus pulposus of the affected disc Although a large part is usually degenerate and fragmented and some may be displaced posteriorly through an annular defect not all the nuclear tissue is necessarily abnormal but all, whether normal or abnormal, must be removed if consistently good results are to be achieved. This complete removal of nuclear tissue has three objectives

1 One of the aims of operation is to relieve the patient's immediate symptoms Severe symptoms, when present, are secondary in nature being produced by displaced nuclear fragments and the removal of such sequestra abolishes these symptoms dramatically

2. If any part of the nucleus pulposus is allowed to remain further retropulsion of nuclear fragments may produce a recurrence of the patient's acute symptoms. This is particularly liable to happen quickly if loose fragments which are *not* actually displaced at the time of operation are overlooked, but degenerative changes and further fragmentation may occur in previously normal nuclear tissue

3 The third object is the establishment of the most favourable conditions for healing. The end result of the successful treatment of a disc lesion is the formation of a firm fibrous tissue scar which occupies the intervertebral space within the annulus. While such a scar has not the properties of a normal disc it is tough and stable and there is in fact a fibrous ankylosis of the affected joint. The presence of degenerate nuclear fragments appears to embarrass the formation of such a scar and if any part of the nucleus is allowed to remain intact it may subsequently be the site of degenerative changes which retard the healing process.

To the primary aim of operation may be added in special circumstances, a secondary aim—the surgical fusion of the damaged intervertebral joint. Those who advocate such a procedure point out that this joint can never be restored to normal and that the ultimate objective of treatment is the establishment of a stable ankylosis. This being so it is argued that it is better to plan the surgical procedure so that rapid bony fusion may be achieved While this is a sound theoretical conception such procedures are justifiable only if an ankylosis can be obtained with certainty and without an undue increase in the difficulties of operation or of post-operative management

PRINCIPLES OF OPERATION

There is no standard and uniformly accepted procedure for dealing surgically with a lumbar disc lesion. Many different techniques are advocated and practised and no two surgeons employ exactly the same method Variations are of two types, basic differences of principle in the method employed and individual variations in the details of technique. The former are important and merit detailed consideration while the latter are of less significance.

As far as the removal of an abnormal nucleus pulposus is concerned *the only* difference in principle between the various methods employed lies in the exposure and in particular in the method of opening the spinal canal.

On one hand *it is obviously desirable that as little damage as possible should* be done to other structures and in particular it is important that the stability of the lumbar spine should be preserved On the other it is essential that the exposure *should be adequate so that any type of* lesion or lesions *which* exist *may* be located and dealt with In many ways these two attributes of the ideal exposure are mutually contradictory and cannot be combined completely in any single technique.

The methods of approach in common use fall into three classes those which are designed to avoid any damage those which are intended to provide the fullest possible exposure and those which attempt to combine both these advantages.

Of the first the best example is the interlaminar or fenestration approach. Using this method no bone at all is removed both spinous processes and laminae

being left intact When the erector spinae muscles on one side have been stripped and retracted the ligamentum flavum is removed from one interspace and the spinal canal is explored through the aperture between the laminae While this procedure has the advantage of doing the least possible damage it has several grave disadvantages. The exposure so procured is extremely limited (Fig 48) Lesions

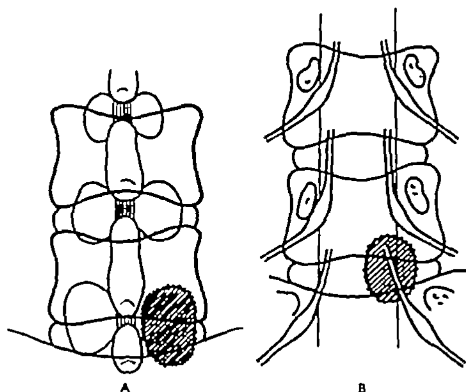


FIG. 48

Interlaminar or fenestration approach

The amount of bone removed (A) and the exposure afforded in relation to the spinal theca and the extrathecal roots (B) is indicated in the diagrams.

associated with an obvious unilateral single protrusion can be found and dealt with easily through such an approach but not all are of this nature The concealed or degenerate disc is difficult to identify and certain types of displaced sequestra and bilateral protrusions are quite inaccessible through a single interlaminar exposure Moreover each such approach affords access to one disc only and unless the exposure is duplicated at two levels both the L 4 L 5 and L.5 S 1 discs cannot be inspected as a routine measure in all cases If this is not done double lesions will inevitably be missed from time to time.

A wide and adequate exposure can of course, be provided by the ordinary laminectomy The muscles are stripped and retracted on each side and the spinous processes and laminae are removed from the fourth and fifth lumbar vertebrae together with the spinous process and part of the laminae of the first sacral segment. If the surgeon wishes to explore the fourth or fifth lumbar roots as they pass through the foramina this is easily done by removing the posterior articular

processes (Fig 49) Such a wide exposure is, however neither necessary nor desirable It is possible that the removal of the laminae and spinous processes weakens the lower lumbar spine and it is certain that removal of the articular processes materially affects the stability of the low back If fusion of the affected segment of the spine should subsequently become necessary such widespread removal of bone makes this an extremely difficult if not impossible procedure using the ordinary technique.

Since both these types of exposure have obvious disadvantages many attempts have been made to devise a satisfactory *compromise between the two extremes.* When attempting to plan such an approach the function of the various parts of the neural arch should be borne clearly in mind.

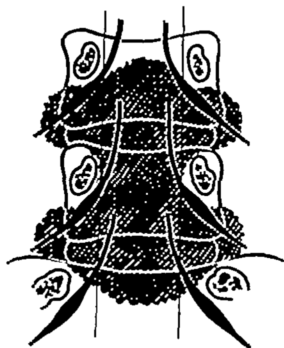


FIG. 49
Full laminectomy approach
A complete laminectomy with removal of the articular processes affords a wide exposure of the spinal theca and the extra thecal roots.

The posterior articular facets form an integral part of any intervertebral joint and contribute materially to the stability of this joint. Any damage to these facets most definitely weakens the low back and *any approach which involves such* damage is undesirable.

The main function of the spinous processes and laminae is to afford attachment for the spinal muscles and ligaments. *Removal of one spinous process does not* disturb the function of the erector spinae muscles since these quickly gain attachment to the fibrous scar which subsequently forms The continuity of the interspinous *and supraspinous ligaments is, however* interrupted. Removal of one lamina or one half lamina does interrupt the continuity of the ligamenta flava but not more so than the interlaminar approach which involves division of these ligaments.

As far as the stability of the lumbar spine is concerned therefore a hemi laminectomy approach *with removal of one spinous process* is more damaging than the interlaminar approach only in that the continuity of the inter and supra spinous ligaments is interrupted Opinions about the importance of *this feature differ It has been suggested* that the stability of the spine is thereby materially and permanently diminished and that a condition which has been called a sprung back may result. *Those who have had frequent opportunities to re-explore spines* previously exposed by such an approach cannot fail to be impressed by the strength and solidity of the massive fibrous tissue scar which bridges the gap This scar may be less resilient than the normal ligaments but it can *hardly be less strong* The author feels that removal of a spinous process may therefore be associated

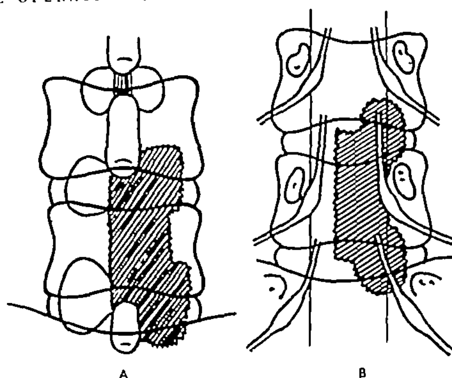


FIG 50

Hemilaminectomy approach

The amount of bone removed (A) and the exposure afforded in relation to the spinal theca and the extrathecal roots (B) is indicated in the diagrams

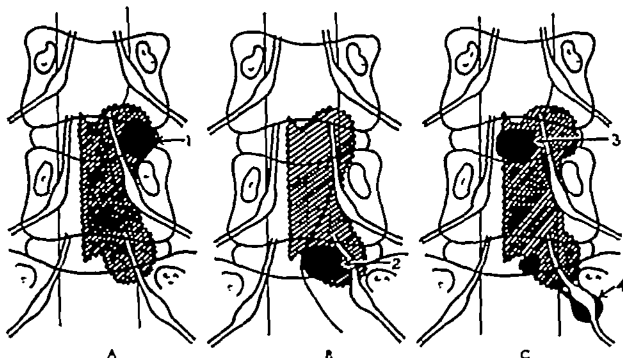


FIG 51

Types of lesion accessible through hemilaminectomy approach

Through a hemilaminectomy approach a *parathyzal* (1) *protrusion* (A) *or* a paracaudal (2) protrusion are easily accessible The central *protrusion* (3) *or the* displaced sequestrum (4) are also *relatively easily reached* (C)

with some subsequent decrease in the elasticity of the low back but that it is not associated with any loss of stability nor is the function of the spinal muscles disturbed.

The approach by means of a hemilaminectomy with removal of one spinous process has many advantages It affords an excellent exposure of two discs (Fig. 50) and through it any type of lesion can be dealt with easily (Fig. 51) As far as subsequent arthrodesis is concerned the removal of a spinous process and lamina does not preclude the use of any of the usual techniques indeed one of the most popular of the methods in common use necessitates the removal of one process The hemilaminectomy can easily be converted into a complete laminectomy if a bilateral lesion exists and this extension does not further weaken the lumbar spine

The author considers that the hemilaminectomy with excision of one spinous process approach is the best possible compromise between the more extreme types of exposure Through it two discs are completely accessible, the stability of the spine is little affected and subsequent arthrodesis, should this prove necessary can be performed without difficulty

If after exposure and examination of two discs using a hemilaminectomy approach it should become necessary to examine a third disc this should be done through an interlaminar approach. It would, of course, be simpler to extend the hemilaminectomy incision for this purpose but removal of a second spinous process and half of another lamina might make subsequent arthrodesis, should this become necessary more difficult. In these special circumstances the interlaminar approach is adequate since, two discs having already been exposed the intention of the surgeon is to inspect one more disc only

If an arthrodesis of the spine is contemplated many different methods may be employed Sound bony ankylosis may be achieved by any of these but none are uniformly successful Indeed it is probable that quite a high percentage of failures occur with all techniques and that in the past there has been a great deal of unjustifiable complacency about the efficacy of all such procedures. This matter will be discussed in the chapter dealing with arthrodesis of the spine

CHAPTER XV

THE OPERATIVE TREATMENT OF LUMBAR DISC LESIONS

(Continued)

TECHNIQUE OF OPERATION

THE surgical removal of the nucleus pulposus of one of the lumbar intervertebral discs is not usually of itself a particularly difficult procedure. Consistently good results following operation depend however on a uniformly sound operative technique and are not easily achieved Neither the type of lesion nor the structure of the lower lumbar spine are constant and anatomical or pathological inconsist encies may lead to various surgical errors which in turn produce unsatisfactory results

The ideal technique should be sufficiently standardised to be capable of being repeated again and again with certainty and yet sufficiently flexible to be easily adapted to any structural abnormality which may be present. The surgeon must be completely familiar with the anatomy of the lumbar spine in all its variations, and with the very different types of disc lesions which may be encountered

Much of this knowledge is, of course the result of special experience of a region in which exposure is of necessity always limited and in which the presence of the cauda equina and the spinal theca makes gentleness and care imperative if crippling and permanent injury is to be avoided For this reason there can be little doubt that the surgical treatment of a disc lesion is usually best undertaken by those who because of some special circumstance, have to undertake it most frequently In principle any surgical monopoly is undesirable for many reasons, but there is much to be said for the point of view of those surgeons who hold that the exploration of an abnormal lumbar disc should not be undertaken as an occasional procedure but that all such lesions in any particular geographic region should be referred to one surgeon or group of surgeons, who thus have an oppor tunity to become thoroughly familiar with all the varying problems associated with this particular procedure

PRE-OPERATIVE LOCALISATION OF THE LEVEL OF THE AFFECTED DISC

Before operation, the level of the abnormal disc should be determined as accurately as possible. The approach can then be planned so that this disc is easily accessible.

By far the most important factor in localisation is clinical evidence of involve ment of one root in its extrathecal course and when low back pain alone is present it is not usually possible to determine the level of the lesion with certainty Radio-

logical changes are of considerably less value and should only be accepted with reserve.

In the ordinary way localisation of the level is primarily based on the assumption that there is a normal sacral plexus and five mobile vertebrae in the lumbar region, but it must be remembered that neither of these factors is constant.

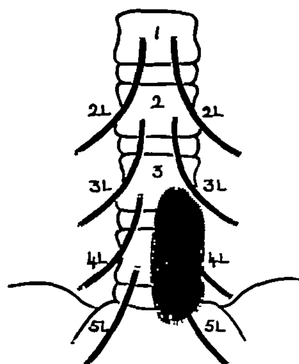


FIG. 52

Exposure with four mobile lumbar vertebrae

When because of sacralisation of the fifth lumbar vertebra there are only four mobile vertebrae in the lumbar region, hemilaminectomy of the lowest free vertebra exposes the L.3 L.4 and L.4 L.5 discs and the associated fourth and fifth lumbar roots.

No reliable statistics exist regarding the incidence of a pre or post fixed sacral plexus but this is probably not an excessively rare phenomenon The presence of a pre fixed plexus brings the nerve roots into relationship with a disc at a level one higher and a post fixed plexus at a level one lower than usual. Only in exceptional circumstances can the presence of such a plexus be suspected before operation but the possibility should always be investigated when in spite of clear clinical evidence exploration fails to reveal a lesion at the expected level.

Abnormality in the number of mobile vertebrae in the lumbar region can of course be detected by radiography before operation When such abnormalities are due to variation in the number of ribs, they have no surgical significance in relation to lumbar disc lesions. When due to lumbarisation of the first sacral vertebra (plate 15) or sacralisation of the fifth lumbar vertebra (Plate 16) their effect on disc root relationship must be remembered when surgical exposure is contemplated

If the fifth lumbar vertebra is sacralised so that there are four mobile segments in the lumbar spine, a hemilaminectomy of the lowest free vertebra which is the fourth lumbar will expose the L.3 L.4 and the L.4 L.5 discs with the associated fourth and fifth lumbar roots (Fig. 52) If sacralisation of the fifth lumbar vertebra is complete and if the sacral plexus is normal, the first sacral root is no longer in relationship with any intervertebral joint and cannot be involved in a disc lesion

When the first sacral vertebra is lumbarised so that there are six mobile vertebrae in the lumbar spine, a hemilaminectomy of the lowest free vertebra that is of the mobile first sacral vertebra, exposes the L.5 S.1 and the S.1 S.2 discs with their associated first and second sacral roots (Fig 53) The L.4 L.5 disc with the associated fifth lumbar root is not exposed and if a lesion exists at this

level which is in fact the site of almost half of all disc lesions it will not be revealed by such an approach Further when the first sacral vertebra is lumbarised the joint between the first and second sacral vertebrae is rarely normal nor is it a common site for disc lesions The narrowing of the space between these vertebral bodies so commonly visible on radiographic examination is usually due to the rudimentary nature of the joint and not to a disc lesion

In most circumstances therefore in the presence of six free vertebrae in the lumbar region laminectomy of the second rather than of the last free vertebra is indicated (Fig 54)

Before operation the surgeon considers the clinical evidence and the structure of the lumbar spine and then decides on the level of his approach If the operative findings do not then correspond to the clinical signs the possibility of an abnormal sacral plexus must be investigated.

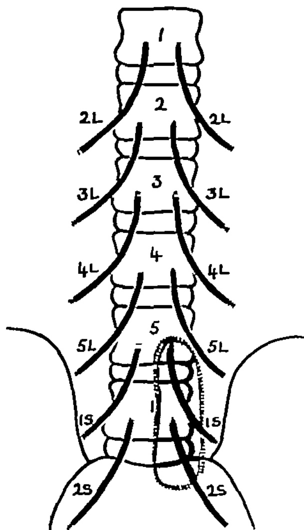


Fig. 53

Exposure with six mobile lumbar vertebrae

When because of lumbarisation of the first sacral vertebra there are six mobile vertebrae in the lumbar region hemilaminectomy of the lowest free vertebra exposes the L.5 S.1 and S.1 S.2 discs and the associated first and second sacral roots

ANAESTHESIA

Because of the position of the patient, intrathecal intubation is the only certain way of avoiding respiratory obstruction during the removal of an intervertebral disc and should be employed as a routine measure

Two drugs should be avoided Cyclopropane because its use is associated with increased haemorrhage from cut bony surfaces and Curare because extreme relaxation of the erector spinae muscles is an embarrassment rather than an aid to the surgeon.

Apart from these points there are no special difficulties about the anaesthetising of a patient for removal of an intervertebral disc. The operation should not be associated with any severe shock or haemorrhage and the patient s condition should not give rise to any anxiety

It is, of course of the greatest assistance to the surgeon if he has the regular services of an anaesthetist who is completely familiar with the surgical technique Supervision of the position of the patient of the adjustment of the lights and of

other details of theatre management, while not part of the anaesthetist's usual duties, are a very real contribution to the efficacy of the surgical procedure.

OPERATIVE TECHNIQUE

The technique to be described is that employed by the author It is not claimed that it is in any way unique, nor is it the only method. It has been evolved during the course of over a thousand operations and, in the opinion of the author it is a satisfactory routine procedure for the exposure and removal of an abnormal nucleus pulposus in the lower lumbar region The position of the patient and the approach employed are based on the method first described by those masters of disc surgery Burns and Young.

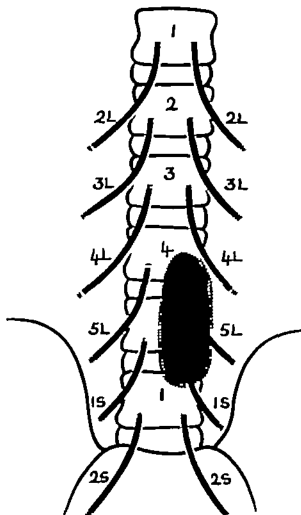


FIG. 54

Exposure with six mobile lumbar vertebrae

When because of lumbarisation of the first sacral vertebra there are six mobile vertebrae in the lumbar region, hemilaminectomy of the lowest free vertebra but one exposes the L.4 L.5 and L.5 S.1 discs and the associated fifth lumbar and first sacral roots.

Position of the Patient and Surgeon

There are three alternative positions in which the patient may be placed—the prone the knee-elbow and the lateral. Of these, the author considers that the last has many advantages from the point of view of the surgeon the anaesthetist and the patient. After being anaesthetised the patient is turned on one side and the hips and knees are flexed fully the knees resting against a padded lithotomy pole A small sandbag is placed below the lumbar region the spine flexed as fully as possible and then fixed with a strip of adhesive strapping passing between the shoulders and the knees. The affected or if the lesion is bilateral the side judged to be most affected is placed uppermost

The surgeon sits on a stool facing the patient. The stool is comparatively low and the table is raised so that the spine is at or jus above the surgeon's eye level. Two assistants are usual and they should sit on each side of the surgeon on rather higher stools. The theatre sister stands behind and on the right of the surgeon

The most effective form of lighting is by means of two powerful spotlights which throw a small beam which can be focussed These lights are placed well back in the theatre, only slightly to each side of the surgeon The lamps are lowered to eye level and then focussed on the patient so that the beams pass over the surgeon s right and left shoulders This ensures complete illumination of the entire depth of the wound

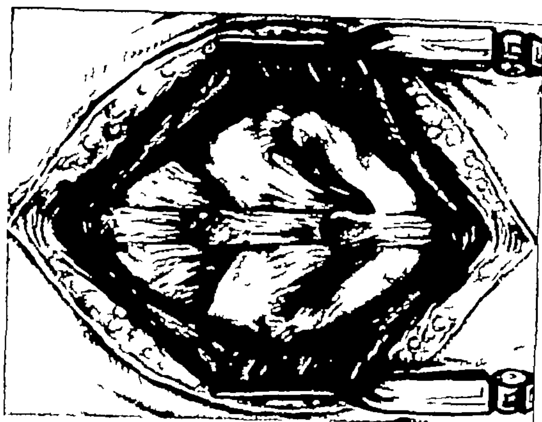
Exposure and Removal of Abnormal Nucleus :

The skin incision is made in the midline over the tips of the spinous processes and if hemilaminectomy of the fifth lumbar vertebra is planned extends from just below the first sacral to just above the fourth lumbar processes Should hemilaminectomy at another level be intended the incision is shifted upwards a corresponding distance Skin and subcutaneous tissue are divided cleanly down to the fascia which is then incised on each side and close to the spinous processes along the whole length of the wound

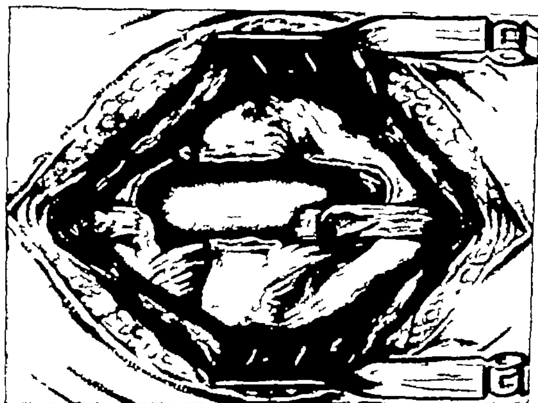
Using a scalpel the attachment of the lumbar muscles to the lateral aspects of the fourth and fifth lumbar and first sacral processes are divided and detachment of the muscle mass is completed by scraping the processes and laminae with a broad bladed osteotome. The laminae are cleared as far lateralwards as the posterior articulations, haemorrhage being controlled by packing swabs between the detached muscle and the bone. By stripping and packing alternately little blood need be lost while the muscles are being separated and this part of the operation should only take three or four minutes. When exposure has been completed the packs are removed and a self retaining retractor is inserted and opened as widely as possible separating the muscle masses

The posterior aspect of the upper part of the sacrum and the posterior surfaces of the laminae of the fourth and fifth lumbar vertebrae with the intervening ligamenta flava are now visible (Plate 19A) When these have been identified with certainty the supraspinous and interspinous ligaments between the fourth and fifth lumbar and the fifth lumbar and first sacral spinous processes are divided After this has been done valuable information can sometimes be gained by testing the stability of the lower two intervertebral joints. The fifth lumbar spinous process is grasped with bone forceps and gently moved from side to side the degree of movement at these joints being noted It should be emphasised again however that the level of the lesion cannot be identified by this test since a disc lesion, depending on its stage may be associated with either an increase or a decrease in the normal joint mobility The fifth lumbar spinous process is now divided at its base and removed and the uppermost half of this lamina is nibbled away from below upwards Because of the attachment of the ligamentum flavum the nibbling starts at the lower free edge of the lamina the deeper blade of the forceps being inserted between the bone and the ligament Only when two-thirds of the depth of the lamina has been removed is the theca exposed

When a hemilaminectomy has been completed the cut edges of the ligamenta flava above and below are picked up and these ligaments are cut away with scissors.



A



B

PLATE 19

Operative exposure of the lower two lumbar discs

A. The spinal muscles have been stripped and retracted. The spinous processes of the 4th and 5th lumbar and 1st sacral vertebrae with the interspinous and supra spinous ligaments are shown. The posterior aspect of the lamina of the 5th lumbar vertebra, together with part of the 4th lumbar lamina and part of the sacrum are exposed with the ligamenta flava between the 4th and 5th lumbar and 5th lumbar and 1st sacral segments.

B The canal has been opened by removing the 5th lumbar spinous process and half of the 5th lumbar lamina, together with the ligamenta flava above and below. This exposes the spinal theca, covered by a little extrathecal intraspinal fatty tissue.

This having been done the exposure is completed by nibbling away a little of the lower edge of the fourth lumbar lamina and the upper edge of the sacrum (Plate 19B)

Such an exposure extends from just below the L.5 S 1 disc to the top edge of the L.4 L.5 disc with their related fifth lumbar and first sacral roots Using two slightly-curved and blunt-ended dissectors the theca is now gently retracted towards the mid line in the region of one of these discs As this is done small lintine swabs with attached threads are packed around the side and in front of the theca above and below the disc to control haemorrhage from the antero-lateral extrathecal venous plexus

When the theca is drawn aside the root and underlying disc are exposed covered by a varying amount of extrathecal areolar tissue and fat The root in its extrathecal course should first be identified cleared and retracted and the ease with which the disc can be exposed and cleared depends on its condition and in particular on whether or not a posterior protrusion is present A normal root is easily seen but a root which has been displaced by or is adherent to a nuclear retropulsion can often only be located by very careful dissection

The findings at this stage of the operation depend on the nature of the lesion of which there are seven different types any of which may be encountered

Perhaps the most obvious type is the retropulsion associated with complete rupture of the posterior longitudinal ligament and extrusions of free nuclear fragments into the spinal canal (Plate 20A) Such fragments may be encountered as soon as the theca is retracted and are easily recognised having the characteristic colour consistency and rolled or crumpled appearance of a nuclear sequestrum. The fragments are usually quite loose and should be gently removed after which the root and the site of the rupture can generally be located Occasionally a single large fragment may have moved away from its point of exit. Such fragments commonly move along the course of the associated nerve root and may be found some distance away from their origin From time to time they are retrieved from the spinal foramen in which they have become impacted A widely-displaced free sequestrum may be difficult to locate but its presence should be suspected when a definite rupture of the annulus and posterior ligament is found without a nuclear fragment in close proximity

The next most easily recognised lesion is the lateral nuclear protrusion Such protrusions are of varying size and the nuclear tissue lies deep to the posterior longitudinal ligament, which is both stretched and partially stripped from its attachment. This type of protrusion can easily be felt but its relationship to the extrathecal root must be determined with great care If the protrusion is para radicular the root is displaced inwards and may be located with comparative ease (Plate 20B) On the other hand if the protrusion is paracaudal the root may be displaced outwards and may be relatively inaccessible, particularly if the spinal canal is the trefoil type (Plate 20C). In these circumstances the root lies in a small lateral recess and is obscured medially by the protrusion and posteriorly by the lateral free edge of the ligamentum flavum and the bony wall of the canal. It should also be remembered that if the protrusion is large the root may be flattened

PLATE 20

THE VARIOUS TYPES OF DISC LESION AS FOUND AT OPERATION

(These colour plates were drawn from lesions exposed at operation For the sake of clarity however the degree of retraction of the theca has been somewhat exaggerated In practice it is both unnecessary and dangerous to retract the theca to the extent depicted.)



A. Rupture of posterior longitudinal ligament with free nuclear sequestra in the spinal canal

A lesion of the L4 L5 disc with rupture of the posterior longitudinal ligament over a nuclear protrusion. Free nuclear sequestra have escaped into the spinal canal and have moved away from the ligament ous defect. Such free sequestra tend to follow the course of the associated extrathecal root.



B. A pararadicular protrusion

A lesion of the L4 L5 disc with a pararadicular nuclear protrusion. The fifth lumbar root in its extra thecal course has been displaced medialwards by the nuclear tumour In such lesions the root is usually adherent to the protrusion.

PLATE 20

THE VARIOUS TYPES OF DISC LESION AS FOUND AT OPERATION

(These colour plates were drawn from lesions exposed at operation. For the sake of clarity, however, the degree of retraction of the theca has been somewhat exaggerated. In practice it is both unnecessary and dangerous to retract the theca to the extent depicted.)



C. A paracaudal protrusion

A lesion of the L.5 S.1 disc with a paracaudal nuclear protrusion. The first sacral root has been displaced outward by the nuclear tumour so that it lies laterally in the spinal canal being covered posteriorly by the lateral free edge of the ligamentum flavum. In such lesions the root is usually adherent to the protrusion.



D. A subrhyzal protrusion

A lesion of the L.5 S.1 disc in which the nuclear protrusion lies directly under the first sacral root. The root is flattened over the summit of and closely adherent to the nuclear tumour. In such lesions it may not be easy to distinguish between the flattened root and the protrusion.

PLATE 20

THE VARIOUS TYPES OF DISC LESION AS FOUND AT OPERATION

(These colour plates were drawn from lesions exposed at operation For the sake of clarity however the degree of retraction of the theca has been somewhat exaggerated In practice it is both unnecessary and dangerous to retract the theca to the extent depicted)



E A central protrusion

A lesion of the L.5 S.1 disc with a central nuclear protrusion The nuclear tumour is medial to and not in direct contact with the associated extrathecal roots. Such lesions are less accessible than the more lateral protrusions.



F A concealed disc lesion (a degenerative lesion)

A degenerate L.4 L.5 disc with no retropulsion of nuclear material. When a degenerate disc of this type has been exposed, a small area which is slightly red and of a definitely softer consistency than the normal disc is found. Such soft spots must be sought with care or degenerate lesions may be missed.

PLATE 20

THE VARIOUS TYPES OF DISC LESION AS FOUND AT OPERATION

(These colour plates were drawn from lesions exposed at operation. For the sake of clarity however the degree of retraction of the theca has been somewhat exaggerated. In practice it is both unnecessary and dangerous to retract the theca to the extent depicted.)



G. A dissecting protrusion

A lesion of the L.4 L.5 disc in which retropulsed nuclear material has spread downwards and inwards under and in the line of the fibres of the posterior longitudinal ligament. The fifth lumbar root is in contact with the upper and outer fringe of the nuclear tumour but the main bulk of displaced nuclear tissue lies lower and more centrally. Such lesions are slightly less accessible than the more localised lateral protrusions and occasionally may involve two roots in their extrathecal course.



H. A dissecting protrusion

A lesion of the L.5 S.1 disc in which retropulsed nuclear material has spread upwards and inwards under and in the line of the fibres of the posterior longitudinal ligament. The first sacral root is in contact with the lower and outer fringe of the nuclear tumour but the main bulk of displaced nuclear tissue lies higher and more centrally. Such lesions are slightly less accessible than the more localised lateral protrusions and occasionally may involve two roots in their extrathecal course.

over and adherent to its summit (Plate 20D) If very flattened such a root is not easily identified

The central type of protrusion is less easily located since it cannot be felt and only becomes obvious when the root and the theca have been freed and retracted almost to the midline (Plate 20E)

A posteriorly-displaced nuclear sequestrum is not always in direct relationship to its point of exit from the annular rupture Two types of displaced sequestra exist, the dissecting and the free. The dissecting sequestrum lies deep to the posterior longitudinal ligament, which it strips from its attachment. Commonly these sequestra lie in the line of the ligamentous fibres, that is, either upwards or down wards, and towards the midline, but they may on occasions spread in any direction. Such dissecting retropulsions are not so easily located as the more common para rhyzal or paracaudal types of protrusion (Plates 20G and H)

If there is no nuclear protrusion a concealed lesion of the degenerate type may be present. This cannot be found until the disc has been carefully cleared and palpated and its presence is indicated by a small area of softening in the posterior annulus (Plate 20F)

At this stage of the operation the posterior surface of the disc and associated root in its extrathecal course should be clearly exposed The disc is carefully palpated and the nature and extent of any lesion which is present is determined The lateral and anterior aspects of the theca above and below the affected disc and root are firmly packed with lintine swabs so that the whole area of the lesion is isolated. The root is gently retracted medialwards the retractor retaining it in this position and protecting it from damage

The disc lesion itself is then dealt with If the posterior ligament has ruptured, any free nuclear sequestra are identified and removed. The point of rupture itself is next investigated, loose tags of annulus and posterior ligament being cut away and the opening enlarged so that the centre of the disc is accessible When a nuclear protrusion, with an intact posterior ligament is present, an incision is made over the convexity of the posterior bulge This incision may be either cruciate or better circular and care must be taken to avoid damaging the veins or roots as it is made. If the concealed or degenerate type of lesion is present the incision is made over the softened area in the annulus Quite often nuclear material begins to extrude spontaneously as soon as the incision is made and this material may consist of a solid fragment of fibrous tissue forming a partially or completely separated sequestrum. Such fragments are seized in punch forceps and gently delivered as far as possible Completely separated sequestra may be extracted in their entirety while others have to be punched out. Nuclear tissue is not always in the form of solid fragments—in the degenerate lesions it is soft, mushy and jelly like, containing fibrous strands. This type of tissue can easily be removed with punch forceps, and even scraped out with a small spoon

When such tissue as presents in the annular incision has been removed the remainder of the nucleus must be extracted The interior of the disc is explored with punch forceps and the nuclear tissue is removed piece by piece. The degenerate

this must be dealt with in the manner described. It cannot be too often repeated that exposure of this second disc is never a formality double lesions are present in between 10 and 20 *per cent. of all patients.*

If exposure of the two lower discs fails to reveal a lesion the surgeon must decide whether his diagnosis is completely at fault or whether there is any possibility of a lesion being present at a higher level. *If the clinical picture has been characteristic*, the disc above must be explored and inspected No more bone should be removed but the incision should be prolonged upwards and the muscles stripped on the affected side so that *the posterior aspects of the laminae at the required* level are exposed The ligamentum flavum between these laminae is incised, removed and if necessary the exposure is improved by nibbling away a little bone at the laminar edges Through this approach the suspected disc can be seen and palpated and any lesion which may be present can be dealt with in the manner already described.

The wound is more easily closed if when the intraspinal part of the operation has been finished the patient s spine is extended a little so that the muscles are relaxed. These muscles are drawn together with two or three tension sutures, the fascia is closed with interrupted sutures, and the skin incision is then closed A dressing and pressure bandage are applied

The Recording of the Operation :

Much valuable information is lost because of poor recording of the operative findings, and records are often so vague and variable as to be valueless.

The author has a uniform method of recording the operative findings, partly in diagrammatic form The following points are always noted the degree of mobility between the vertebrae the condition of the ligamentum flavum the type and site of any disc lesion which is found the presence of nuclear sequestra and the degree of root adherence, compression or tension. The findings are tabulated and incorporated in the case records together with a diagrammatic representation of the condition of the discs and roots.

POST-OPERATIVE MANAGEMENT

The post-operative management should be planned to extend over a full year and before operation the programme should be outlined to the patient, who is warned that complete co-operation is necessary if the best possible result is to be achieved Although the broad outlines of the programme are always essentially the same, the details naturally vary from individual to individual The surgeon should therefore be familiar with the occupation domestic background and temperament of each patient and must be prepared to assist, encourage or restrain when necessary

The programme can be considered in various stages, each of which leads to the next During the whole time the patient is kept under observation and examined at regular intervals

Immediate Post-operative Period

The patient should be kept in bed for at least three weeks after operation. No useful purpose is served by endeavouring to get a patient up and walking in a few days, a course which is advocated by some surgeons. No matter how dramatic the immediate relief may be, it must be remembered that the intervertebral joint is of necessity irritable after removal of the nucleus pulposus and that as with any irritable joint, rest rather than activity is indicated

The maximum post-operative discomfort occurs during the first 48 hours, the second 24 hours being rather worse than the first. The degree of discomfort varies a great deal, depending on the individual and on the severity of the pre operative symptoms. When pain has been very intense operation usually affords an immediate and dramatic relief and the patient is much more comfortable after than before. If on the other hand the symptoms were quiescent with only moderate or slight discomfort the immediate post-operative pain is relatively more severe and more noticed

During the first week the patient is nursed with one pillow only but is allowed to lie in any position which may be comfortable. Full doses of Penicillin are given for four days and sedatives and analgesic drugs are exhibited when necessary One week after operation the patient should be fairly comfortable and able to move freely in bed without assistance The patient should still be nursed with one pillow and should not sit up in bed. At this stage gentle extension exercises may be commenced but the physiotherapist should understand clearly that their object is to restore tone to the extensor muscles and not to increase the range of movement of the lumbar spine.

One complication may arise about this time When the root in its extrathecal course is very adherent and therefore a certain amount of unavoidable handling is necessary as it is being dissected free, sciatic pain, at first completely abolished by operation may recur to some extent between the fifth and tenth day This recurrence is usually slight and persists for four or five days only although occasionally it may be more severe and persist for two or three weeks before gradually disappearing. Such a recurrence of pain is probably associated with some oedema or bruising of the involved root.

During the third week the patient should still be kept as flat as possible and allowed one pillow only

Twenty-one days after operation the patient is allowed to get out of bed. Starting with a few minutes in a chair and a few steps about the room activity is gradually increased and in four or five days walking for ten minutes at a time or sitting in a chair for two or three hours should be possible without discomfort At this stage a lumbar corset with incorporated Goldthwait steels is worn at all times when out of bed.

About four weeks after operation the patient should be fit to return home and the second stage of convalescence begins The first, or hospital, stage is of course, a little variable and some people seem to recover more quickly than others.

However comfortable the patient may be, the period of three weeks in bed should not be reduced materially and if the surgeon is in any doubt or if recovery seems a little slower than usual bed rest should be continued for four or five weeks if necessary Quite often patients who have been kept in bed longer than usual subsequently appear to be more comfortable and to progress more rapidly than patients who have been allowed to get up at an earlier stage

General Management after leaving Hospital :

After leaving the hospital the patient begins a period of gradually increasing activity which should ultimately lead to a full and normal life During this time the patient s activities are planned and the whole period should be divided into several stages. Management during this time is, however based on simple principles and restrictions cannot be either too rigid or completely universal The basic aims are a steady increase in activity within the limits of the patient s tolerance, complete avoidance of any flexion strains on the lumbar spine, and the treatment of any exacerbation of symptoms by rest. It should be remembered that even after *operation symptoms tend to be episodic and recovery is usually spasmodic rather* than regular The patients should be warned about this tendency lest they become discouraged when minor remissions occur or when their condition appears to be stationary for three or four weeks at a time

One to Three Months after Operation :

Having returned home one month after operation the patient must not at once resume a normal life

For a further month activity should be markedly restricted. Late rising and early retiring with a midday rest are desirable. Mild exercise may be taken in the form of walking perhaps twice a day starting with short walks lasting for about ten minutes and gradually increasing up to about three-quarters of an hour Stooping, lifting or any strenuous pursuit is, of course, completely avoided. During this time it is often better if the patient does not remain at home A convalescent home or a holiday in suitable surroundings is often more conducive to recovery and this is particularly true of female patients, who are thus spared the inevitable domestic worries and the tasks associated with the management of the home

Two months after operation the patient *should be fit to resume any reasonably* sedentary occupation Long hours of standing should be avoided and nothing strenuous should be attempted. Much depends at this stage on the nature of the patient s occupation. A sedentary worker who can make his own pac[illegible] d particu larly his own hours, may reasonably b[illegible] that it is safe to s[illegible] those who have heavier work in which lo[illegible] inevitable [illegible]ble to resume for a further month Simil[illegible] wife may [illegible] [illegible]s in the home two months after operat[illegible] not do [illegible] is too strenuous. During this time the [illegible] of course, at all times during the day and flexion strains

Three to Six Months after Operation:

Between three and six months after operation the patient resumes normal life gradually The corset is worn at all times during the day flexion strains are avoided as is anything particularly strenuous but no other special restrictions are necessary Certain trades which involve heavy lifting or stooping should not be resumed during this time, but it is usually possible for such workers to begin some modified form of their occupation. During these three months patients are guided by their tolerance for exertion and increase their activities as far as possible without producing pain or discomfort

Six to Twelve Months after Operation:

During this time the patient lives a normal life and resumes all activities Most people have no desire to do anything which might be dangerous and do not present any special problems A few occupations however such as mining and stevedoring, are not safe at this stage, and very often in these circumstances the best solution is a permanent change to some lighter types of work Certain pursuits such as hunting and rugby are also inadvisable and it is best to attempt to persuade the patient to abandon these at least temporarily

During this stage the question of discarding the corset may also be considered. Many patients become so accustomed to its support and derive so much benefit from it that they prefer to retain it permanently This of course is the safest of all courses and should not be discouraged A few find the corset almost intolerably uncomfortable and do not appear to derive much help from its support These cannot usually be persuaded to retain the support for more than a month or two The remainder may be allowed to discard their corset at any time between six and twelve months, depending on their symptoms At first this is left off during the evenings and at weekends and if no untoward effects follow it can be discarded for longer and longer periods and finally dispensed with altogether

Examination of the Patient during the Post-operative Period

During the post-operative period the surgeon should see his patient at regular intervals and should advise about activity and mode of life

Two factors must always be considered—the symptoms and the clinical findings. Irritability of an affected intervertebral joint is indicated by spasm of the erector spinae muscles and pain on and limitation of spinal movement. Root irritation is shown by limitation of straight leg raising and by sciatic pain. Symptoms associated with these findings should be treated by rest and immobilisation of the spine graduated in accordance with their severity

Note should also be taken of the residual symptoms of interference with root function. Sensory loss gradually returns over a period of some months Muscle weakness or wasting also recovers gradually but when the tendon reflexes are absent they do not usually return in less than one year and in many cases remain permanently impaired.

RE-EXPLORATION OF THE LOWER LUMBAR DISCS

The surgeon who specialises in the treatment of lumbar disc lesions must be prepared to undertake two procedures in addition to the removal of an abnormal nucleus pulposus in the ordinary way

In certain circumstances a disc which has been operated on already must be re-explored. This can be, and usually is, considerably more difficult than exploration of a previously undisturbed spine and requires certain special technical ability

Further in a certain percentage of patients the removal of an abnormal nucleus is not enough to produce complete relief of all symptoms arthrodesis of the damaged intervertebral joint, either immediately or as a late second stage procedure, is necessary Arthrodesis is discussed in a subsequent chapter

INDICATIONS FOR RE EXPLORATION

If a patient with a lumbar disc lesion has persistent or recurrent symptoms after operation there appears to be a general tendency either to abandon all treatment, on the grounds that the patient is incurable, or to advise arthrodesis irrespective of the nature of the residual complaints. It is surprising how rarely re-exploration is advised or undertaken, and yet this measure is indicated in almost half of all patients in whom a previous operation has failed.

The indications for re-exploration will be discussed more fully in a subsequent section, but essentially they are extremely simple. If the clinical evidence suggests that the patient is suffering from an active lesion of one of the lower lumbar discs, as opposed to an irritable intervertebral joint, three possibilities must be considered. A lesion which was not located at the previous operation may exist an abnormal nucleus may not have been removed completely so that subsequent nuclear sequestration has produced further symptoms or rarely a disc normal at the previous operation may since have undergone degenerative changes. Any one of these circumstances may constitute a clear indication for re-exploration and the results of a second operation are usually entirely satisfactory Re-exploration is not therefore in any way a measure of despair

TECHNIQUE OF OPERATION

Two factors complicate the technique of re-exploration—the presence of scar tissue produced by the previous operation and distortion of the normal anatomy following the removal of bone and ligamentous structures. Both these factors are variable and much of the technical difficulty of the procedure depends on the degree of variation

The amount of scar tissue present varies with the damage done at the first operation. Structures which have been handled gently and repaired accurately heal with much less scarring than those which have been bruised and traumatised. Any post-operative wound infection greatly increases both the amount of fibrous tissue and the adherence between adjacent structures.

The method of exposure employed at the first operation determines the extent of anatomical variation from the normal Paradoxically the more limited the first exposure and the less the amount of bone removed the easier technically it is to re-explore the region

1 Position of Patient

The placing of the patient on the operating table the position of the surgeon and his assistants and the lighting arrangements are exactly the same as for a first exploration

2 Exposure of Canal:

Before operation, the amount of bone previously removed is determined radiologically and the level of the discs to be explored decided on.

The second incision is made through the scar of the previous operation and is carried down to the fascial scar Two small flaps of skin and subcutaneous tissue are dissected up so that the deep fascia is clearly exposed

If an interlaminar approach has been employed no bone being removed the stripping of the erector spinae muscles is comparatively simple. The muscle attachments to the spinous processes are divided with a scalpel and muscle stripping is completed with an osteotome in the usual way The spinal canal and its contents are protected by bone and stripping can be carried out quite confidently so long as the surgeon keeps over the laminae and away from the scarred area at the site of the former interlaminar point of entry to the canal.

When a spinous process or spinous processes have been removed, together with part or all of a lamina, the muscles are no longer attached to bone at the site of the former operation and the canal and its contents are not protected but are covered by a dense fibrous tissue layer the deep surface of which is adherent to the theca. In these circumstances, great care must be taken in approaching the canal through this scar if damage to the theca or cauda equina is to be avoided. The erector spinae muscles are first freed and retracted. This is done by sharp dissection the muscles being separated from the scar tissue until they are free and can be drawn widely apart with a self retaining retractor

3 Exposure of the Theca:

When no bone has been removed one spinous process is cut off at its base and a hemilaminectomy is carried out in very much the usual way Care must be taken in the region of the interlaminar scars, but once the theca has been exposed by removal of bone above or below this area it is comparatively easy to separate and remove the scar tissue piece by piece

When hemilaminectomy or laminectomy has been performed previously the contents of the canal are embedded posteriorly in a mass of fibrous tissue This is first thinned as much as possible by sharp dissection and then slowly stripped from the theca with a blunt dissector During this stripping great care must be taken to avoid tearing or damaging the theca itself

When the posterior aspect of the spinal theca has been cleared along the whole length of the wound, the discs and their related roots are located by working around the lateral and on to the anterior aspect of the canal This area is also the site of adhesion formation, the degree and extent of which depend on the nature of the previous surgical interference. Haemorrhage is controlled by packing with lintine swabs, and the root is first identified, cleared and retracted so that the underlying disc is exposed The disc itself is then inspected and palpated and any lesion present identified There should be no hesitation in exploring the interior of such a disc if there is any doubt at all about the presence of nuclear abnormality The two lower discs must always be explored and lesions found dealt with in the manner already described

4. Wound Closure

The wound is closed in the usual way care being taken to approximate the erector spinae muscles accurately

5. Damage to the Spinal Theca

At this stage some mention should be made of one of the complications which may arise during re-exploration. Unless the exposure of the contents of the canal is carried out with the greatest care, the theca may be cut or torn open. Should this happen, cerebrospinal fluid leakage is at once controlled by tilting the head of the table downwards, and the thecal tear is repaired if possible by suture and failing this, by the use of a muscle patch During the subsequent closure of the incision the greatest possible care should be taken to approximate the various layers with accuracy as this repair helps to prevent subsequent leakage from the site of the thecal opening.

POST-OPERATIVE MANAGEMENT AFTER RE EXPLORATION

After uncomplicated re-exploration the post-operative management is exactly the same as after a first exploration.

If however the theca has been opened, the patient should be nursed with the foot of the bed raised on blocks for a week and during this time should be kept in either the lateral or the prone position This reduces the intrathecal pressure and prevents cerebrospinal fluid leakage through the unhealed thecal defect

CHAPTER XVI

THE OPERATIVE TREATMENT OF LUMBAR DISC LESIONS

(*Continued*)

ARTHRODESIS OF A DAMAGED INTERVERTEBRAL JOINT

IT has been emphasised already that treatment whether operative or conservative cannot restore to normal a lumbar intervertebral joint in which degenerative disc changes have already taken place.

Operative removal of an abnormal nucleus establishes favourable conditions for healing and with suitable after-treatment a firm fibrous ankylosis of the damaged joint may occur spontaneously the patient then being free from symptoms

A painless ankylosis is not achieved in all cases, however and an irritable or arthritic joint is associated with chronic low back pain and disability In these circumstances, the only measure which will afford complete and permanent relief is surgical fusion of the abnormal joint.

Such a fusion may be carried out as a primary procedure in association with exploration of the lower lumbar discs and removal of all abnormal nuclear tissue or it may be reserved for a late second stage operation in selected patients.

From time to time immediate arthrodesis in all patients has been advocated by certain surgeons, who claim that by combining fusion of the damaged joint with extirpation of the abnormal nucleus the best possible results can be ensured While this may be true as a theoretical conception certain difficulties arise which justify objections to the combined operation

In favour of immediate arthrodesis it must be admitted that a successful fusion of the damaged joint carried out in association with complete removal of the degenerate nucleus appears to be the ideal surgical treatment for a lumbar disc lesion

Against immediate arthrodesis the following arguments may be advanced

1 Fusion is unnecessary in a high proportion of patients who are completely relieved by removal of the abnormal nucleus and effective after treatment.

2. The addition of arthrodesis increases the difficulties and severity of the operation to some extent While this increase is not sufficient to contraindicate the procedure in any way it must in some measure add to the immediate operative risk

3 After removal of a diseased nucleus the after treatment is relatively simple and the patient is only confined to bed for three or four weeks On the other hand, following an arthrodesis the after treatment involves a long period of complete immobilisation of the lumbar spine and the patient should be nursed flat in a plaster bed for about two months after which a plaster jacket is worn for a further three to four months There can therefore be no comparison between the relative periods of disability and the amount of discomfort and inconvenience following simple

removal of an abnormal nucleus and removal of such a nucleus combined with immediate fusion of the affected intervertebral joint.

4 Bony ankylosis of an intervertebral joint is not easily achieved and in fact in quite a high percentage of patients sound fusion does not follow operation. Since uniformly successful results are by no means assured arthrodesis of the affected joint cannot be regarded as a simple extension of the operative removal of the affected disc. If attempted a completely new series of problems, hazards and complications arise.

5 Arthrodesis or attempted arthrodesis does not make the complete removal of all degenerate nuclear material any less essential to the complete relief of symptoms. Should incomplete nuclear removal make re-exploration subsequently necessary this procedure is considerably complicated by the presence of a posterior bone graft or grafts.

6 Finally the one argument which would be overwhelmingly in favour of an immediate arthrodesis that is, demonstrably better results than those following simple removal of the nucleus, cannot be supported by the published results of operative series In fact, the results of the extirpation of the nucleus combined with immediate arthrodesis seem to be if anything a little worse than those which are produced by simple removal of the diseased nucleus.

In the opinion of the author arthrodesis of the affected joint cannot be justified as an immediate and routine measure in all patients operated on for disc lesions Arthrodesis should be reserved for a late and second stage procedure in selected patients and should only be carried out immediately in special circumstances.

INDICATIONS FOR ARTHRODESIS

Immediate arthrodesis is indicated in two special circumstances

1 When a disc lesion is found in association with a spondylolisthesis Fusion of both the disorganised joint and of the joint which is the site of the nuclear change *is usually advisable. Unless this is done some permanent weakness* of the low back is almost inevitable

2 If a disc lesion of some years standing is associated with marked arthritic changes in the affected joint in a patient of vigorous habit or strenuous occupation the surgeon should consider the advisability of immediate arthrodesis. In such patients the possibility of residual symptoms due to an irritable or arthritic joint is much higher than if the lesion is uncomplicated by degenerate joint changes

There is one indication for arthrodesis as a late second stage procedure

3 When materially incapacitating residual symptoms are present and are produced by an irritable or arthritic intervertebral joint arthrodesis of this joint is indicated

AIMS OF ARTHRODESIS

The aim of arthrodesis is simple enough, to produce bony fusion between the vertebrae above and below the affected joint, thus rendering this joint functionless and abolishing all symptoms originating from it

In theory this may be done in two ways

The intervertebral joints both anterior and posterior may be extirpated completely and exposed or raw bony surfaces on each vertebra brought into direct and intimate contact with each other Then provided absolute immobilisation is maintained for a sufficiently long period and the blood supply to the raw surfaces is adequate direct bony union between the vertebrae will ultimately take place. In these circumstances union may be accelerated and immobilisation reinforced by the use of autogenous bone grafts which may be placed in several ways. The function of such grafts is however ancillary arthrodesis depends primarily on direct union between the vertebrae.

While this method is theoretically ideal in practice it is impracticable To remove the articular cartilage from the posterior articular facets completely involves breaking up the articular processes so much that they can no longer be brought into stable contact. Even more important the vertebral bodies cannot be brought into apposition until the intervertebral disc is removed in its entirety nucleus, annulus and cartilagenous end plates alike. Complete extirpation of an inter vertebral disc in this way is so technically difficult as to be impractical

The second alternative is more practical and is almost universally employed. By this method the affected joint is bypassed by a bone graft or grafts. When these become firmly incorporated with the vertebrae above and below and provided they are sufficiently strong and rigid, the bypassed joint is firmly fixed and the mechanical stresses to which it is normally subject fall on the grafts Although the insertion of such grafts in various sites is a simple enough surgical procedure it is not easy to achieve complete incorporation of the grafts nor to ensure that they are sufficiently strong. These difficulties are discussed in a later section

PRINCIPLES OF ARTHRODESIS

It has already been stated that there are different techniques which may be employed to stabilise an intervertebral joint using a bypassing bone graft or grafts Some of these were originally evolved in the treatment of tuberculosis of the spine and it should be remembered that in this condition ankylosis is often relatively easily achieved since destruction of the disc and bony collapse produce conditions favourable for bony fusion once the infection has become quiescent. Indeed in many such patients spontaneous ankylosis must have taken place since the surgical procedures carried out were so cursory and mechanically ineffective that they could have had little effect on the stability of the damaged joint

When dealing with lumbar disc lesions the problem is not as simple Destruction of the disc is not on a sufficiently large scale to produce spontaneous bony fusion of the affected joint, and it is only in the very late stages and under favourable conditions that fibrous ankylosis occurs. In the early stages the deranged joint may be less stable than normal so that sound ankylosis is not easily produced surgically To meet these difficulties many different techniques have been evolved.

It has already been pointed out that in theory the ideal method would be to produce direct bony contact between the vertebrae themselves particularly in the

region of the vertebral bodies. This is impracticable involving as it does complete extirpation of the entire intervertebral disc.

In practice therefore the techniques employed consist of the implanting of a bone graft or grafts in various sites. The very multiplicity of these methods suggests that no one is entirely satisfactory as is indeed the case

The author considers that there are four essential features of a satisfactory technique

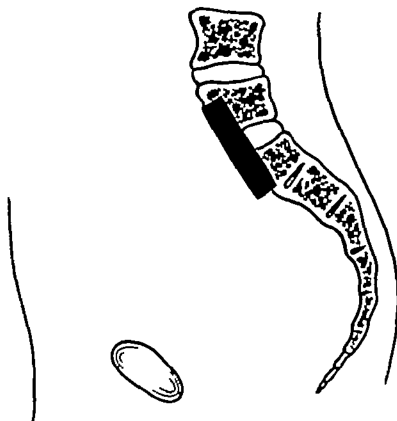


Fig. 55

The anterior graft

Through an anterior approach a free graft or double grafts may be inserted between the fifth lumbar body and the sacrum

Intimate contact should be achieved between large areas of raw bone on the host vertebrae and the graft or grafts

This contact should be stable, that is the grafts should be fixed firmly in position

The operative technique should be relatively simple and safe It is an added advantage if the approach to the spine is that used in removal of the disc so that where necessary these two procedures can conveniently be combined

Finally and this is much more important than it might seem the penalty for failure should not be too high If the grafts fail to become incorporated and subsequently become displaced from their bed there should be no danger of their coming into contact with and pressing on vital or delicate structures

In an attempt to achieve the ideal arthrodesis the vertebrae have been approached from almost every aspect and all kinds of grafts have been used

An anterior approach may be employed and a graft or grafts inserted between the fifth lumbar vertebral body and the sacrum Using an extraperitoneal approach a tibial graft is inlaid into the fifth lumbar body and the sacrum (Fig 55) It may be inserted on one side or centrally or bilateral grafts may be used This method first devised for spondylolisthesis, is not often used in the treatment of disc lesions probably because orthopaedic surgeons do not readily use the anterior approach to the spine At the same time on some occasions this procedure may be useful to fuse the L 5 S 1 joint when the posterior approach is contraindicated for any reason

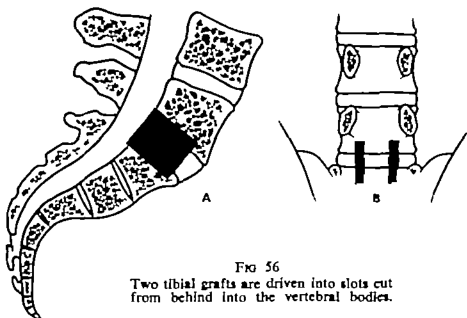


Fig 56
Two tibial grafts are driven into slots cut from behind into the vertebral bodies.

A technique which has been devised more recently and which has enjoyed some popularity is the insertion of tibial grafts between the vertebral bodies This is carried out in association with removal of the nucleus After the disc has been exposed and dealt with slots are cut into the vertebral bodies with a suitably shaped osteotome Into these tibial grafts are driven so that they cross the disc space (Fig. 56) At first a very high percentage of success was claimed for this method but more recently various surgeons have reported a very large proportion of failures (Adkins[1]) In the experience of the author this method is not only not reliable but has one further very serious disadvantage. In some cases the grafts fail to fuse and become displaced posteriorly and protrude into the spinal canal where they cause serious pressure symptoms The removal of grafts displaced in this way can be an extremely difficult and dangerous procedure.

[1] Adkins, E. W O (1955) Lumbo-sacral arthrodesis after laminectomy *J Bone Jt Surg* 37 B, 208 223

Another method which has recently become more popular is the use of the transverse processes for arthrodesis (Adkins [2] Watkins[3]) Through a postero-lateral approach grafts are placed on or between the transverse processes of the 4th and 5th lumbar vertebrae and the sacrum (Fig. 57) This procedure is *quite* reliable and is particularly useful when the more usual posterior arthrodesis would be difficult or impossible because of previous removal of spinous processes and laminae The approach being postero-lateral this technique cannot conveniently be combined with removal of the disc. In the opinion of the author a higher percentage of success is likely to be achieved if bilateral grafts are used. This involves two or more separate incisions and makes the operative procedure more prolonged

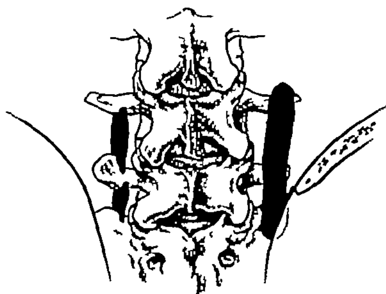


FIG. 57

The transverse processes may be used for arthrodesis of the spine Grafts may either be laid on or fixed between the processes and the sacrum.

The method most widely practised is to attempt through a posterior approach to produce a solid bony bar between the spinous processes or laminae of adjacent vertebrae by means of a free graft or grafts (Fig. 58) This is not quite the simple matter it might appear It is not easy to ensure firm bony union between both ends of the free grafts and the spinous processes or laminae nor are the grafts necessarily strong enough to stand up to the stresses to which they are subsequently subjected Further it has been shown by Unander Scharen[4] that firm bony union between a graft or grafts and the spinous processes alone is not enough to stabilise the joint completely The grafts must therefore be fixed to the posterior aspects of the laminae and posterior articulations if they are to be completely effective.

[2] Adkins, E. W O (1955) Lumbo-sacral arthrodesis after laminectomy *J Bone Jt Surg* 37 B, 208 223

[3] Watkins, M B (1953) Posterolateral Fusion of the Lumbo-sacral Spine. *J Bone Jt Surg* 35-A, 1014 1018

[4] Unander Scharen, Lars (1950) On low back pain with special reference to the value of operative treatment with fusion. *Acta orthop scand.*, Suppl. No 5

One of the most ingenious methods is the employment of an H shaped graft of iliac bone One spinous process is removed the graft is slipped into position with

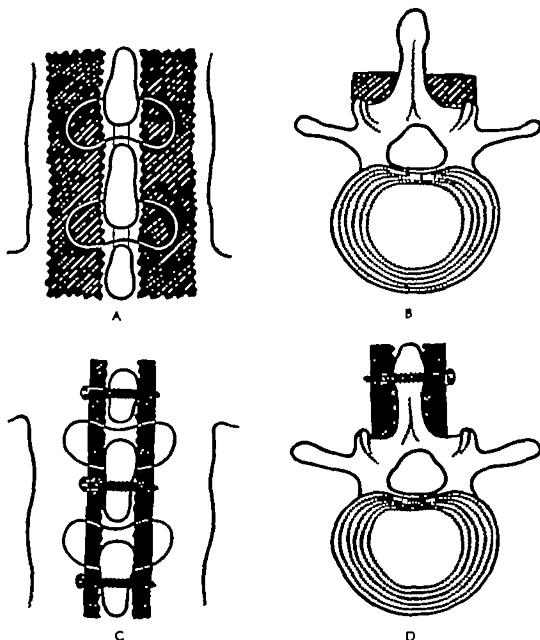
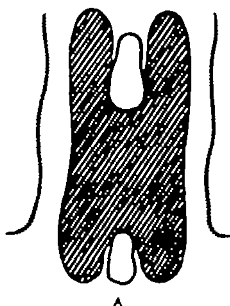


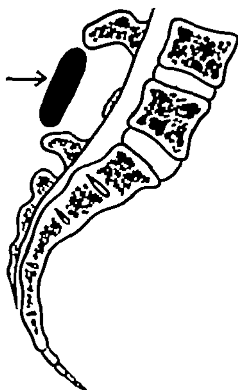
FIG 58

Types of double posterior grafts

Double grafts of tibial or iliac bone may be laid flat on the laminae on each side of the spinous processes (A and B), being held in place by the spinal muscles which are sutured over them. Alternatively similar grafts may be laid on the lateral surfaces of the spinous processes, being fixed in position by transfixing screws (C and D)

the spine fully flexed and becomes firmly locked in position when the spine is extended (Fig. 59). In all these procedures the graft or grafts may be supplemented by the use of bone chips.





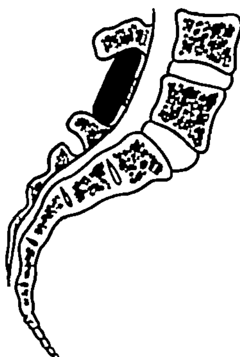


FIG. 59

The H-shaped iliac graft

The H-shaped iliac graft lies on the posterior surface of the laminae after one spinous process has been removed (A) To spring this graft into position the spine is flexed so that the transverse bar of the H just slips between the spinous processes above and below (B). The spine is then extended and the graft is locked in its bed (C).

It has always been obvious that sound ankylosis of the posterior articulations themselves would effectively fix an intervertebral joint Attempts to secure such an ankylosis may be made in various ways none of which are completely satisfactory If the joints are opened up so that the articular cartilage may be removed damage to the processes themselves destroys their important mechanical contribution to the stability of the intervertebral joint Transfixion of the posterior joints by screws inserted through drill holes as suggested by King[1] may fix these articulations temporarily but it is only a matter of time before pressure absorption allows the screws to become loose and ineffective Perhaps the most promising method is one suggested in a personal communication by H A Brittain to the author the fixation of the joint by large autogenous pegs inserted through drill holes If these drill holes and the pegs are sufficiently large a considerable area of articular cartilage is destroyed and if the joints are protected subsequently for a sufficiently long time the grafts should ultimately consolidate completely

In the author's opinion the best technique in most circumstances is the use of an H shaped graft of iliac bone applied to the posterior surfaces of the laminae and articulations and locked into position by the spinous processes above and below The graft should be liberally reinforced by bone chips and every effort should be made to secure the most favourable possible conditions for union between the graft and the laminae. The graft beds are prepared with care and the graft fixed as securely as possible and subsequently protected from movement and stresses until consolidation is complete.

To this some form of fixation of the posterior articulations by means of auto genous pegs driven across these joints may be a valuable addition

Some consideration of the joint to be fused is essential Grafts extending from the posterior surface of the laminae of the fourth and fifth lumbar vertebrae to the posterior surface of the sacrum fix the L.4 L.5 and the L.5 S 1 articulations *In the vast majority of patients the lesion is situated at one or other of these joints* or at both and extension of this arthrodesis is only necessary in those few patients in whom the lesion occurs at a higher level

PRE-OPERATIVE MANAGEMENT

Before operation the preparations for post-operative immobilisation should be made. The only really effective way of ensuring complete fixation of the lumbar spine immediately after operation is by means of a plaster bed or double hip spica, no alternative form of splinting being nearly so efficient

About a week before operation a posterior plaster shell is made and a suitable frame for this bed is prepared For three or four days before operation the patient is nursed in this shell so as to become accustomed to the position Since this form of immobilisation is only continued for about two months it is not strictly necessary to prepare an anterior as well as a posterior shell in order to turn the patient into the prone position from time to time to relieve skin pressure on the back. At the

[1] King, Don (1948) Internal fixation for lumbo-sacral fusion. *J Bone Jt Surg.*, 30-A, 560-565

same time it is usually wise to prepare such a shell although it is better not to disturb the patient unless pressure symptoms arise and not to use the anterior shell unless it becomes necessary

TECHNIQUE OF ARTHRODESIS

The method to be described is the posterior approach arthrodesis effected by means of free grafts laid on the posterior surfaces of the laminae. Double grafts of tibial or iliac bone or a large H shaped iliac graft as suggested by Bosworth,* are used

Position of Patient

When arthrodesis is being carried out as a late second stage procedure without accompanying re-exploration of the discs and roots the patient may either be placed prone on the operating table or in the lateral position If fusion is carried out in conjunction with exploration or re-exploration of the discs the lateral position is used and it is quite unnecessary to turn the patient face down when the grafts are being inserted

The author himself prefers to use the lateral position in all circumstances and considers that operative shock is greatly reduced if the abdominal and thoracic pressure inevitably associated with the prone position is avoided.

Exposure

The posterior surface of the upper half of the sacrum and spinous processes and laminae of the fourth and fifth lumbar vertebrae are exposed by stripping and retracting the lumbar muscles in the manner already described This exposure is less troublesome in patients in whom the lower lumbar spine has not been explored previously when the approach is complicated by scar tissue and removal of bone.

Preparation of Grafts and Graft Beds

Tibial grafts have the advantage of being strong and massive although some surgeons believe that they are less osteogenic than iliac bone Two grafts of suitable length are readily cut from the subcutaneous surface of one tibia.

Iliac grafts can be cut from the posterior surface of one iliac bone, about half the thickness of the ilium being used Double grafts or a single large fragment of bone which can be shaped into an H are easily cut with an osteotome and at the same time an ample supply of bone chips can be obtained

Graft beds are prepared by cleaning the posterior surface of the laminae and sacrum very thoroughly When all traces of muscle attachment have been removed the bone is made raw by removing shavings of the outer cortex with an osteotome (Plate 21A)

* Bosworth, D M (1945) Clothespin Graft of the Spine for Spondylolisthesis and Laminal Defects. *Amer J Surg* 67 61-67

PLATE 21

ARTHRODESIS USING H-SHAPED ILIAC GRAFT



A. The graft bed prepared. This bed extends from the fourth lumbar lamina to the sacrum. The spinous process of the fifth lumbar vertebra and half the lamina has been removed in the exposure of the lower two discs and their associated roots.



B. The graft in position. The H shaped iliac graft has been sprung into position with the spine in full flexion. When the spine is extended the graft is locked by the fourth lumbar and first sacral spinous processes. The spinal muscles, which are retracted to show the extent of the graft, are later sutured together

Insertion of the Grafts

If double grafts are used these are placed in position in the graft beds and packed around with bone chips. It is important that the grafts should be curved to coincide with the shape of the lumbo-sacral spine so that they lie flat and snug in their beds. Iliac grafts are sufficiently soft to be easily bent to the desired curve but tibial grafts are more difficult to shape The inner surface of the grafts is placed downwards so that there is intimate contact between raw bone on the graft and graft bed

There is no completely satisfactory method of securing double grafts to the laminae. The use of metal screws or plates is undesirable and the best fixation is achieved by suturing the erector spinae muscles firmly together at the mid line so that they cover and hold the grafts very securely

From the mechanical point of view the most attractive type of graft is that made from the iliac bone in the shape of an H When this is used the fifth lumbar spinous process is cut off at its base and small notches are cut in the upper surface of the base of the first sacral process and lower surface of the base of the fourth lumbar process These processes are then separated as far as possible by full flexion of the spine and the graft is shaped so that the transverse bar of the H can just be slipped between the separated processes. The spine is then extended and the graft is gripped very securely between the approximated processes, the upper and lower edges of the transverse bar slipping into the notches which have been cut in their bases (Plate 21B) The fixation which can be secured in this manner is very complete and a properly shaped H graft is immovably locked in its bed when the spine is extended Bone chips are then packed round the graft and the muscles are sutured over it in the usual way

Fixation of Articular Facets

If an attempt is made to combine the insertion of a free graft with arthrodesis of the posterior articulations this is in the author's opinion best done by means of transfixing pegs.

The posterior surfaces of the joints are exposed by carrying the muscle stripping outwards a little further than usual. The joints are best located by following the lower edge of the laminae downwards and outwards until it ends at the joint line. The direction in which the planes of the articular surfaces lie should be borne in mind These surfaces are usually described as being in the antero-posterior plane except for the lumbo-sacral facets which are in the transverse plane In fact, however the lower articulations are *usually quite markedly curved so that the* anterior halves are almost transverse while the posterior halves turn backwards and lie only slightly lateral to the sagittal plane Normally this posterior curving is less marked or absent in the lumbo-sacral facets (Figs 60A and 60B). Variations in the planes of the facets are common and one or both of the L.4 L.5 articulations may resemble the lumbo-sacral articulations.

Using a quarter inch drill which is directed outwards at an angle of 45 degrees and slightly downwards the articular processes are drilled so that both articular

surfaces and both processes are penetrated Providing the drill is held in this plane (Figs. 60c and 60D) and stopped once the inferior process is pierced there should

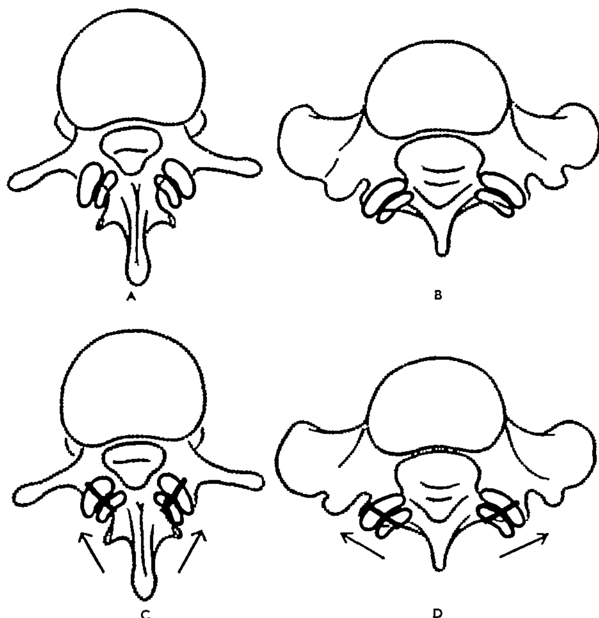


FIG. 60

The plane of the articular surfaces of the posterior articulations

Although it is usually said that in the lumbar region the articular surfaces of the posterior articulations lie in the antero-posterior plane with the exception of the lumbo-sacral articulations which are in the transverse plane this is not strictly accurate. All the articular surfaces are slightly curved, the lumbar being more or less antero-posterior (A) and the lumbo-sacral more or less transverse (B) The direction in which transfixing pegs should be inserted to fix the interlumbar (C) and lumbo-sacral (D) joints is indicated

be no danger of damaging a nerve root either in or after it has left the foramen Bone pegs cut to a suitable size and length are then hammered into the drill holes so that they traverse and fix the posterior joints

Closure of Incision:

The incision is closed in the usual way care being taken to suture the erector spinae muscles firmly over the grafts.

POST-OPERATIVE MANAGEMENT

There is very good evidence to suggest that free grafts used to fix an inter vertebral joint do not become united to their beds for at least four months and it is probable that in most cases six months or more is necessary before consolidation is complete. If surgical arthrodesis is to be successful in a high proportion of cases it is therefore necessary to maintain complete fixation of the lumbar spine and to protect the grafts from strains during this time.

One of the difficulties which arises in post-operative management is that it is almost impossible to determine whether or not consolidation has in fact taken place Clinical examination is never conclusive in that it is impossible to determine on clinical grounds whether any movement is taking place at the L.4 L.5 or L.5 S 1 joints. Ordinary radiographs give no useful information iliac bone being hardly visible at all and while tibial grafts can be seen there is no certain means of telling whether they have united to the laminae or not. The only investigation of any value is to have radiographs taken with the spine in various degrees of flexion to see if the affected joints do in fact move and even with a series of such radiographs it is difficult to be certain about individual joint movement. In fact, the period of immobilisation is largely empirical and for this reason the only safe course is to immobilise the spine and protect the grafts for six months in all cases.

When the wounds have been sutured a dressing is applied and the patient is placed in the posterior plaster shell Immobilisation in this shell is continued for eight weeks, the patient being left undisturbed during this time if possible. Should pressure symptoms arise the patient may be turned into an anterior shell and nursed face downwards for as long as may be necessary

Eight weeks after operation the shell is discarded and the plaster jacket applied, the patient being allowed to get up as soon as the plaster is dry Within a week or two the patient should be getting about normally in plaster and may engage in any sedentary occupation. Immobilisation in the plaster jacket is continued until six months after operation, the jacket being changed from time to time whenever it becomes loose

At the end of this time the plaster is removed and an attempt is made to determine by clinical and radiographic examination whether or not the arthrodesis is sound. If the findings appear satisfactory the plaster is replaced by a lumbar corset with incorporated Goldthwait steels which is worn at all times during the day for a further six months. During this time the patient is careful to avoid all flexion strains on the spine but otherwise activities are normal.

If one year after operation the patient is symptom-free and if the joints appear soundly fused the corset may be discarded and the patient may safely engage in any occupation or any form of activity

From time to time fusion of the grafts to the laminae may be delayed and in these circumstances immobilisation in a plaster jacket should be continued for longer than usual

In a small proportion of patients the grafts never unite and in such cases the surgeon must decide in the light of the patient's symptoms whether to accept whatever degree of fibrous ankylosis may be present or whether to make a second attempt to achieve bony ankylosis by surgical means either by repeating the procedure or employing some alternative technique.

FAILURE OF ARTHRODESIS

The percentage of patients in whom solid bony ankylosis may be expected after operation is a matter of some controversy The published results vary very widely and are probably of questionable significance In the author's opinion the actual results do not depend so much on the method employed as on operative technique and the efficiency of the aftertreatment. These vary so very widely that he considers that the percentage success probably ranges between over 80 per cent. in some hands and less than 10 per cent. in others

There are four main causes of failure.

Sufficiently large areas of vascular bone are not exposed on the host vertebrae.

The contact between these areas and suitable surfaces on the graft or grafts is not sufficiently intimate.

Following operation the graft and its bed is not protected completely from movement and mechanical stresses, or protection is not maintained for a sufficiently long period.

The graft or grafts are not sufficiently massive No matter how well incorporated they may become or how much they may hypertrophy they are simply not strong enough to stand up to the strains to which they are subjected

CHAPTER XVII

THE OPERATIVE TREATMENT OF LUMBAR DISC LESIONS

(Continued)

THE various operative procedures which may be necessary in the treatment of lumbar disc lesions have been discussed already together with the pre and post-operative management appropriate to each

It now remains to consider the results which may be expected after surgical treatment and even more important, to attempt to analyse the possible causes of failure, together with their prevention diagnosis and treatment.

THE RECORDED RESULTS OF OPERATIVE TREATMENT

Too much significance should not be attached to the recorded results of operative treatment. So much depends on the selection of suitable cases, on the experience and technique of the surgeon and on the post-operative management of the patient that the results particularly in small series may be quite misleading. Moreover in many instances sufficient time has not elapsed between operation and review to produce a real end result. Indeed it would be difficult to state categorically when such a result may be claimed since secondary arthritic changes in the affected intervertebral joint may occur insidiously over a period of many years.

Some information may however be gained by considering the recorded results in large series of patients operated on by different surgeons The author has collected from the literature published between 1937 and 1949 the recorded results of operations performed on some four thousand patients by 38 different surgeons or groups of surgeons. On the average in approximately 62 per cent. of all patients the results were excellent or good in 17 per cent. there was some improvement after operation and in 21 per cent the results were unsatisfactory A very wide variation between the different series was however noted For example, in ten of the records unsatisfactory results were less than 10 per cent., while in six unsatisfactory results occurred in more than 40 per cent. of patients.

Every practising surgeon who operates on large numbers of disc lesions will know how meaningless any unqualified and general statements on the results to be expected after operation must be The type of lesion the duration of symptoms, the age occupation and habit of the patient and many other factors affect the prognosis and must be taken into consideration in each individual case The author himself has now operated on more than one thousand patients with lumbar disc lesions Any detailed analysis of the results would be out of place here but it is true to say that in general in his experience there is no other group in which a

major surgical procedure has afforded so much satisfaction to both p[illegible] surgeon

UNSATISFACTORY RESULTS FOLLOWING OPERATION

Unsatisfactory results following operation do not just occur for no re[illegible] are produced by various and different circumstances. Many are due to the s[illegible]comings of surgery, others are caused wholly or in part by ill advised po[illegible]t op[illegible] management and some are unavoidable.

Moreover most of these conditions are amenable to treatment, either sur[illegible] or conservative. There is far too general a tendency to accept op[illegible]rative f[illegible]ilur[illegible] as irreparable and abandon further treatment, whereas in fact most of th[illegible] p[illegible]tients can be salvaged by appropriate measures.

The first step in the treatment of such a patient is an accurate diagno[illegible] the cause of failure. This is a most important matter as the treatment to b[illegible] [illegible]d depends entirely on the pathological condition which is present.

The causes of failure may be classified and fall into four groups.

GROUP ONE (DISC)

In the first group the source of the residual symptoms is a lesion of th[illegible] itself and in most cases the lesion is that which originally caused the patient's pre-operative troubles. The persistence of most of these conditions is due to errors in the operative technique and their existence is therefore under the direct control of the surgeon.

1 Failure to Locate Lesion

A lumbar intervertebral disc lesion may be present but may not be found at operation. This usually happens in one of three ways.

(*a*) A limited exposure may be carried out at the wrong level. If the spinal canal is opened by an inter laminar approach at a level other than that at which the lesion exists the abnormal disc is never seen.

(*b*) The spine may be explored at the proper level but because of a poor exposure or haemorrhage from the extrathecal veins the abnormal disc may be obscured and not found or not recognised.

(*c*) The exposure and recognition of the abnormal disc may be a difficult technical problem. Lesions presenting such problems are the central protrusion, the "concealed" disc and the widely displaced nuclear sequestrum. All these may be difficult to expose and recognise, particularly through an inter laminar approach.

Diagnosis. If a lesion exists and is not recognised at operation the patient's symptoms persist unchanged. If such symptoms are typical a negative exploration should not be accepted as conclusive evidence that a disc lesion does not exist.

Treatment. In these circumstances the appropriate treatment is re-exploration of the lower lumbar discs. If the lesion is then found and dealt with the prognosis is as good as if the operation had been successful in the first instance.

2. Failure to Recognise a Double Lesion

In between 10 and 20 per cent. of all patients both the L 4 L 5 and the L 5 S 1 discs are affected simultaneously and the presence of such a double lesion cannot always be recognised clinically If in these patients, one disc only is exposed and dealt with residual symptoms produced by the second lesion are inevitable.

Diagnosis These patients have persistent symptoms typical of a disc lesion at a level other than that at which the lesion was found.

Treatment Re-exploration with exposure and inspection of the two lower lumbar discs is indicated Again if a previously undetected lesion is found and dealt with the prognosis is good.

3 Failure to Deal with a Bilateral Lesion

Many disc lesions are bilateral, that is they either extend across the mid line or there are two separate retropulsions, one on each side of the mid line Often such discs can only be dealt with adequately if exposed from both sides of the spinal cord and a unilateral exposure is followed by an unsatisfactory result.

Diagnosis Patients with bilateral lesions which have been inadequately dealt with from one side suffer from residual symptoms typical of a disc lesion, the symptoms of root irritation being confined to or most marked on the side opposite to that from which the disc was approached

Treatment The treatment of such lesions is re-exploration the affected disc being exposed from both sides of the spinal theca Here, also if the lesion is found and the nucleus removed completely the prognosis is good

4. Further Retropulsion of Nuclear Tissue

If the nucleus is only partly removed at operation subsequent further retropulsion of nuclear sequestra may be associated with a recurrence of symptoms This may occur either as an early or a late complication If degenerated or sequestrated nuclear tissue has been left within the annulus this may become displaced posteriorly at any time Indeed since the annular defect has been surgically enlarged further displacement often takes place within a few days of operation with a sharp reappearance of symptoms. If on the other hand the nuclear tissue left *in situ* is relatively healthy further sequestration will not occur until it has been broken up by degenerative changes, a process which usually takes several months.

Diagnosis In these patients operation is followed by immediate relief Later however symptoms typical of nuclear retropulsion recur and the patient is then in much the same condition as before operation.

Treatment The treatment indicated is re-exploration of the affected disc and complete removal of its nucleus This procedure is followed by immediate relief of the patient s symptoms and provided the entire nucleus is removed further retropulsion becomes impossible

5. Nuclear Degeneration in a Previously Healthy Disc:

A disc which is healthy at the time of operation may subsequently become abnormal and produce a recurrence of symptoms This cannot of course, be controlled by the surgeon In the author s view however it is a very uncommon cause of post-operative complications and in most cases in which it is alleged to have occurred a double lesion has been missed at operation

Diagnosis Degenerative changes developing after operation in a previously healthy disc are of course associated with the symptoms typically produced by a disc lesion the level of which is not that of the disc previously dealt with

Treatment The treatment of such a lesion should be the same as that of any other untreated disc lesion Should conservative measures fail to produce relief then operation is indicated.

GROUP TWO (ROOT)

The next three conditions which may cause persistent or recurrent symptoms also fall into a group since they are associated with root disorders They are in part associated with failures of operative technique and to this extent they are also under the control of the surgeon

6 Root Damage

The nerve root in its extrathecal course is often adherent to retropulsed nuclear material, particularly in lesions of long standing. The root may be damaged while it is being freed and damage may also be caused by too vigorous retraction.

Diagnosis Root damage at operation is followed by sensory motor or reflex changes in the affected leg These changes may be of any degree and may be temporary or permanent.

Treatment When root changes are produced by contusion or oedema spontaneous recovery takes place, although some months may elapse before this occurs. No special treatment is necessary or is of any particular value in these circumstances. If more serious damage is done—if for example, the root is partly or completely divided—the symptoms produced are permanent and cannot be cured by any form of treatment.

7 Root Adherence

After operation the root tends to adhere to the annular scar through which the diseased nuclear material has been removed This occurs in some degree in all cases and is to that extent unavoidable. At the same time the extrathecal root is particularly liable to adhere to nuclear tissue if this has not been removed completely or to tags of the annulus fibrosus or posterior longitudinal ligament This complication can therefore be prevented or minimised by complete removal of the nucleus and of all loose tags in the vicinity of the root.

Diagnosis Root adherence is associated with symptoms of roots irritation and in particular with pain when the adherent root is stretched either by movement of the extended leg or of the lumbar spine.

Treatment If after operation symptoms of root adherence are present relief is often produced by immobilisation of the lumbar spine in a plaster jacket for a few weeks Should this fail re-exploration and freeing of the affected root may be necessary

8. Permanent Changes in the Nerve Root

If a nerve root has been compressed or stretched by retropulsed nuclear material for too long permanent and irreversible changes may take place in the root itself Operation does not, of course, influence these changes.

Diagnosis In the presence of such changes the symptoms of root disfunction persist unchanged after operation.

Treatment No form of treatment can affect irreversible root changes and impairment of muscle power or sensation are permanent It should be realised that such changes are often the results of procrastination operation having been delayed far too long

GROUP THREE (ARTICULAR)

The third group consists of disorders of the intervertebral articulations.

9 Damage to the Posterior Articular Facets

Disturbance of or damage to the posterior articular facets on one side is regarded as of little importance by some surgeons indeed routine decompression of the nerve root in the foramen is sometimes advocated The author is of the firm opinion that damage to the facets even on one side produces an unstable and therefore an irritable intervertebral joint which is a source of post-operative symptoms.

Diagnosis The symptoms of an irritable or arthritic intervertebral joint are constant low back pain aggravated by exertion and relieved by rest or immobilisation

On examination there is spasm of the lower lumbar muscles and limitation and pain at the extremes of movement of the lumbar spine, all movements being equally affected.

Damage to the articular facets can be demonstrated by adequate oblique radiographs of the lumbar spine

Treatment If the symptoms cannot be controlled by a corset and avoidance of flexion strains surgical arthrodesis of the affected joint is indicated

10 Arthritis of the Intervertebral Joint

Degeneration or removal of the nucleus pulposus disorganises one inter vertebral joint and subsequently arthritic changes are inevitable These changes take place in all three parts of the affected joint but provided post-operative management is adequate a painless fibrous ankylosis is usually achieved If post operative treatment is inadequate or if too great demands are made on the lower lumbar spine a permanently irritable and arthritic joint may be produced It is

surprising how often, between three and six weeks after operation patients are subjected to a course of vigorous spinal exercises and sometimes even to manipulation with the intention of mobilising the lumbar spine. The effects of such ill judged attempts at rehabilitation are invariably most unsatisfactory

Diagnosis The symptoms and clinical findings associated with an irritable or arthritic intervertebral joint have been described already

As arthritic changes advance they become more and more obvious on radiological examination

Treatment Should conservative measures fail to control the symptoms surgical arthrodesis of the affected joint is indicated

GROUP FOUR

The final group consists of two conditions which may appear elementary but which are by no means unknown

11 Post-operative Infection:

Post-operative infection after exploration of a lumbar intervertebral disc is a dangerous and highly undesirable complication which may take the form of wound infection, of a meningitis or of a sub-acute infection between the vertebral bodies themselves.

Diagnosis When a wound infection or meningitis is present the usual signs of infection become obvious a few days after operation and the diagnosis presents no particular difficulties.

A sub-acute infection between the vertebral bodies themselves is an insidious complication characterised by extreme irritability of the affected joint. Ultimately the diagnosis can be confirmed by the radiographic appearance of local changes in the vertebral bodies around the infective focus.

Treatment Meningitis or a wound infection are treated by rest and intensive chemotherapy

A chronic infection between the vertebral bodies is treated by prolonged immobilisation of the lumbar spine in a plaster jacket. Massive doses of antibiotics in the early stages may help to control the infection but complete resolution is always an extremely gradual process.

12. Gross Damage to the Spinal Theca or Cauda Equina

Gross damage to the spinal theca or cauda equina may occur during exposure of the spinal canal or as a result of careless retraction

Diagnosis The diagnosis of gross damage to the spinal theca or the cauda equina is usually only too obvious. A thecal fistula, bladder or rectal symptoms or other neurological sequelae of cauda equina disfunction are present.

Treatment Such complications should not occur as a result of operative exploration of the lower lumbar discs. If they do occur a thecal fistula may be closed surgically but little can be done to repair the results of cauda equina damage

The patient for whom an operation for a lumbar disc lesion has failed to produce relief or in whom symptoms have recurred always presents a difficult problem Only too often such people wander unhappily from surgeon to surgeon and from hospital to hospital without receiving any constructive advice or treatment.

With the passage of time they feel, somewhat naturally that their complaints are not being taken seriously and they tend to develop a functional overlay and to exaggerate their symptoms. The more obvious this tendency becomes the less likely it is that any surgical treatment will be undertaken. Many are ultimately sent for psychiatric treatment which, in the face of an organic lesion is of little value and often only reinforces their sense of frustration.

In direct contrast to the successes these peripatetic monuments to surgical failure consult and are seen by many clinicians and it is to them that a great deal of the prejudice against the surgical treatment of lumbar disc lesions owes its existence

It cannot be too often repeated that in most instances it is possible to determine the cause of such patients symptoms and that most of the conditions which may be present are, like all other disorders associated with lumbar disc lesions, amenable to treatment.

INDEX